

ENGINE 4H SERIES

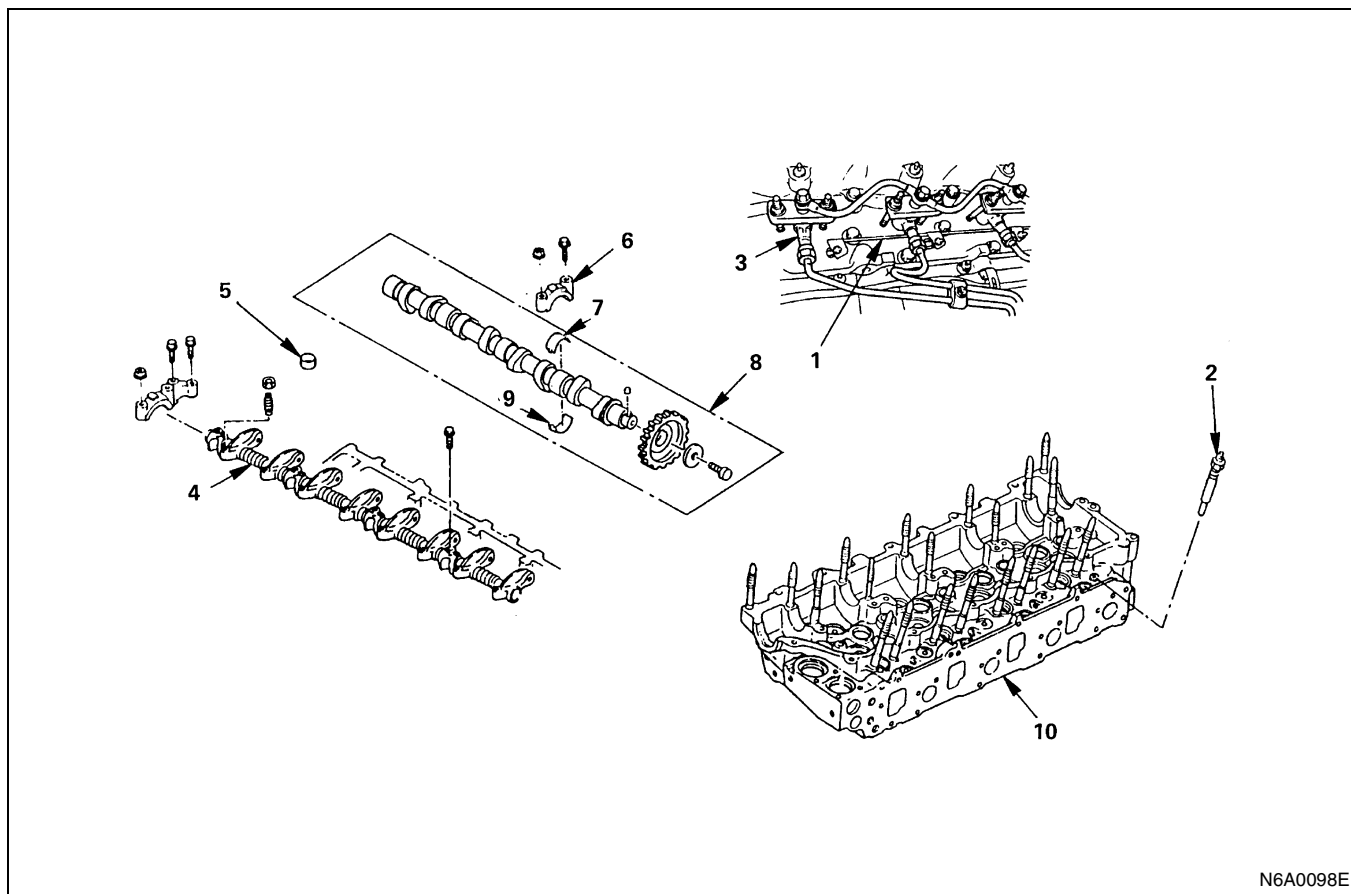
SECTION 6A ENGINE MECHANICAL

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CYLINDER HEAD

Component



N6A0098E

Legend

- | | |
|-------------------------------------|---------------------------|
| 1. Glow plug connector | 6. Camshaft bearing cap |
| 2. Glow plug | 7. Camshaft bearing upper |
| 3. Injection nozzle holder assembly | 8. Camshaft assembly |
| 4. Rocker arm shaft assembly | 9. Camshaft bearing lower |
| 5. Valve cap | 10. Cylinder head |

Notice:

- During disassembly, be sure that the valve train components are kept together and identified so that they can be re-installed in their original locations.
- Before removing the cylinder head from the engine and before disassembling the valve mechanism, make a compression test and note the results.

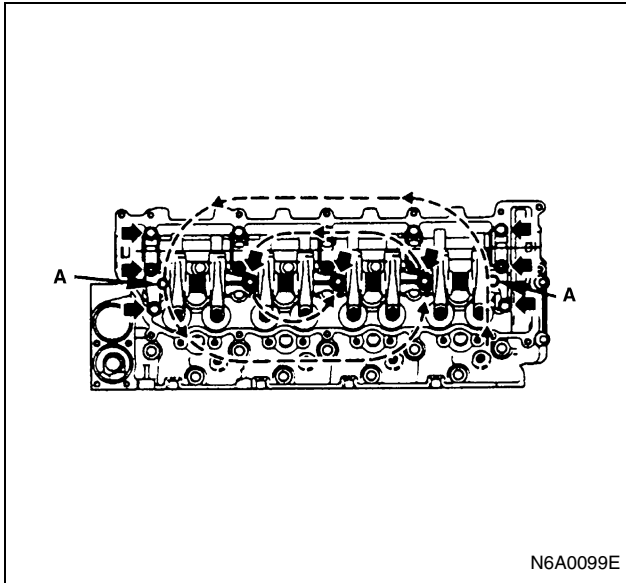
- 1) Loosen the rocker arm shaft bracket nuts and bolts in numerical order a little at a time and remove the rocker arm shaft assembly with the camshaft brackets.
- 2) Leave the (A) indicated bolt unremoved on this occasion, since it is the rocker arm fixing bolt.

Caution:

Failure to loosen the rocker arm shaft bracket nuts and bolts in numerical order a little at a time will adversely affect the rocker arm shaft.

Disassembly

1. Glow Plug Connector
2. Glow Plug
3. Injection Nozzle Holder Assembly
Mark the nozzle holder assemblies fitting positions by tagging each nozzle holder assembly with the cylinder number from which it was removed.
4. Rocker Arm Shaft Assembly



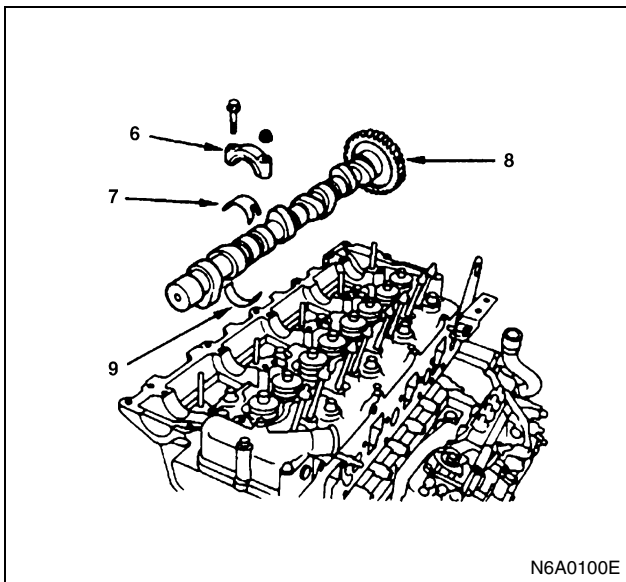
5. Valve Cap

Caution:

Take sufficient care not to let valve caps fall into the gear case or oil return hole.

6. Camshaft Bearing Cap
7. Camshaft Bearing Upper
8. Camshaft Assembly
9. Camshaft Bearing Lower

If the camshaft bearings are to be reinstalled, mark their fitting positions by tagging each bearing with the cylinder number from which it was removed.



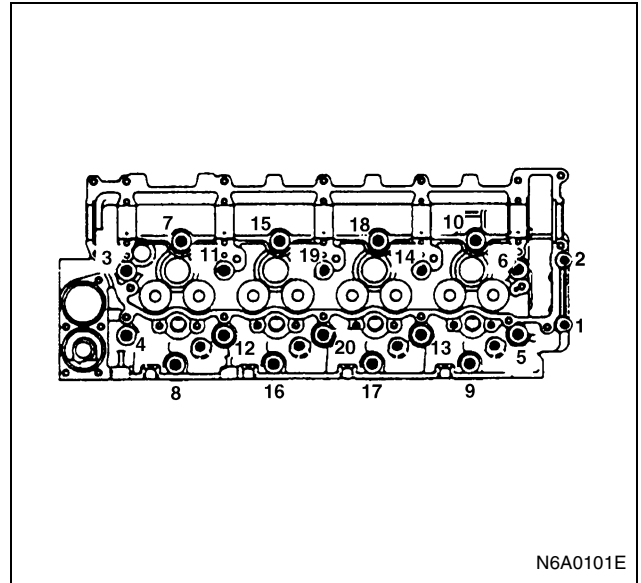
10. Cylinder Head

Loosen the cylinder head bolts in numerical order a little at a time.

Caution:

Failure to loosen the cylinder head bolts in numerical order a little at a time will adversely affect the cylinder head lower surface.

- Refer to Section 6A3 "CYLINDER HEAD".



Clean

- Cylinder head bolts
- Cylinder head

Carefully remove all varnish, soot and carbon to the bare metal. Do not use a motorized wire brush on any gasket sealing surface.

Inspection and Repair

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

- Cylinder head gasket and mating surfaces for leaks, corrosion and blow-by. If the gasket has failed, determine the cause;
 - Improper installation
 - Loose or warped cylinder head
 - Insufficient torque on head bolts
 - Warped case surface

1. Cylinder head bolts for damaged threads or stretching and damaged heads caused by improper use of tools.

Caution:

Suspected bolts must be replaced.

2. Cylinder head for cracks, especially between valve seats and in the exhaust ports.
3. Cylinder head deck for corrosion, sand particles in head and porosity.

Caution:

Do not attempt to weld the cylinder head. Replace it.

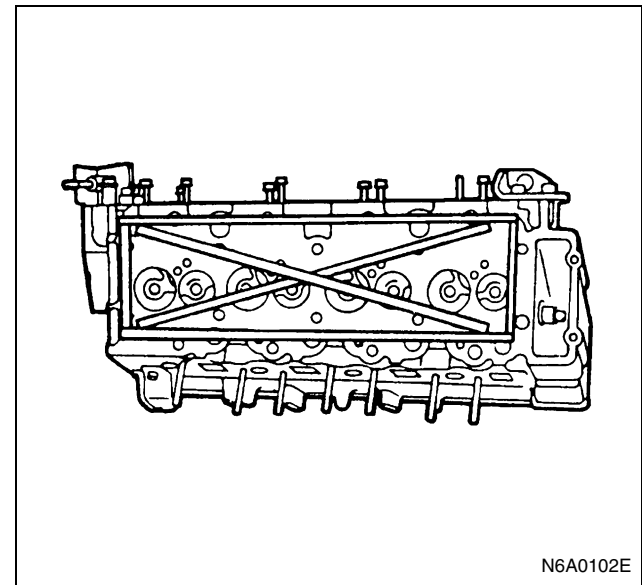
Cylinder Head Lower Face Warpage

1. Use a straight edge and a feeler gauge to measure the four sides and the two diagonals of the cylinder head face.
2. If the measured values exceed the specified limit, the cylinder head must be replaced.

Notice:

Do not regrind the cylinder head lower face.

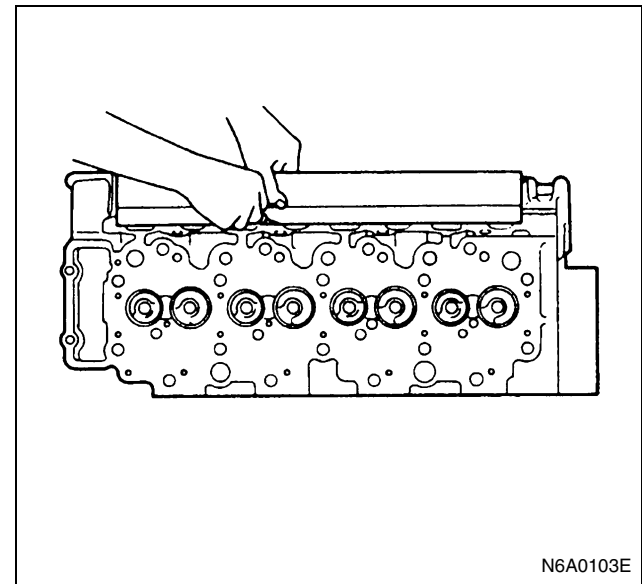
Cylinder Head Lower Face Warpage		mm (in)
Standard	Limit	
0.05 (0.002) or less	0.2 (0.008)	



Manifold Fitting Face Warpage

Use a straight edge and a feeler gauge to measure the manifold cylinder head fitting face warpage. Regrind the manifold cylinder head fitting faces if the measured value is greater than the specified limit.

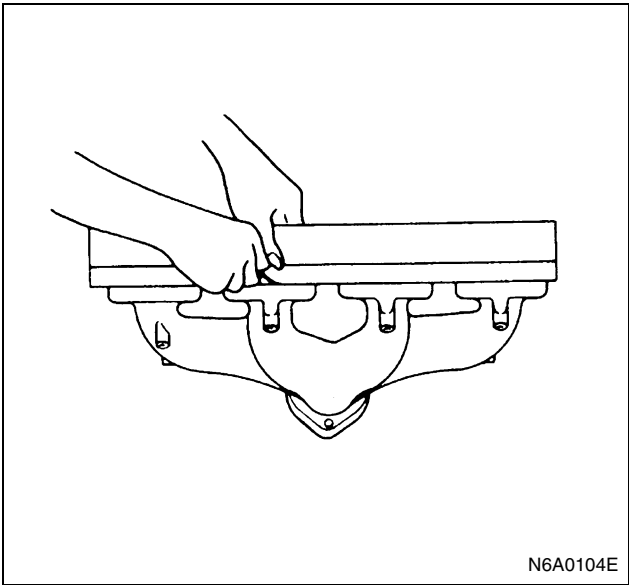
Manifold Fitting Face Warpage		mm (in)
Standard	Limit	
0.05 (0.002) or less	0.2 (0.008)	



Exhaust Manifold Warpage

Use a straight edge and a feeler gauge to measure the manifold cylinder head fitting face warpage. If the measured values exceed the specified limit, the manifold must be replaced.

Exhaust Manifold Warpage		mm (in)
Standard	Limit	
0.05 (0.002) or less	0.24 (0.008)	



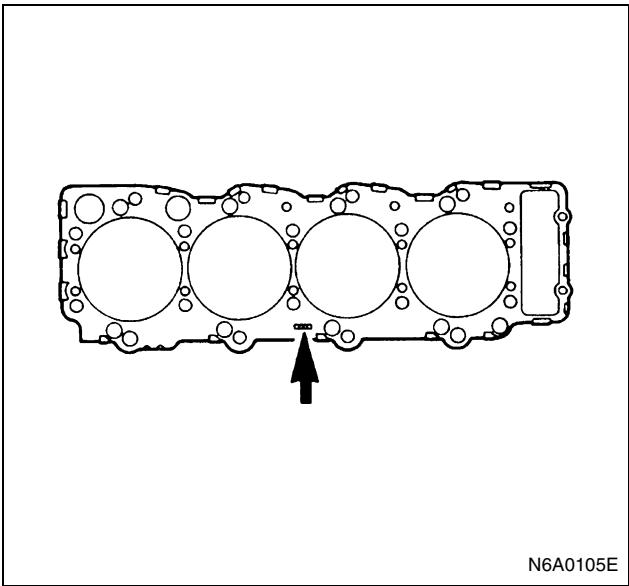
Reassembly

Install the cylinder head gasket with its "PART NUMBER" mark facing up and toward the left of the engine.

Caution:

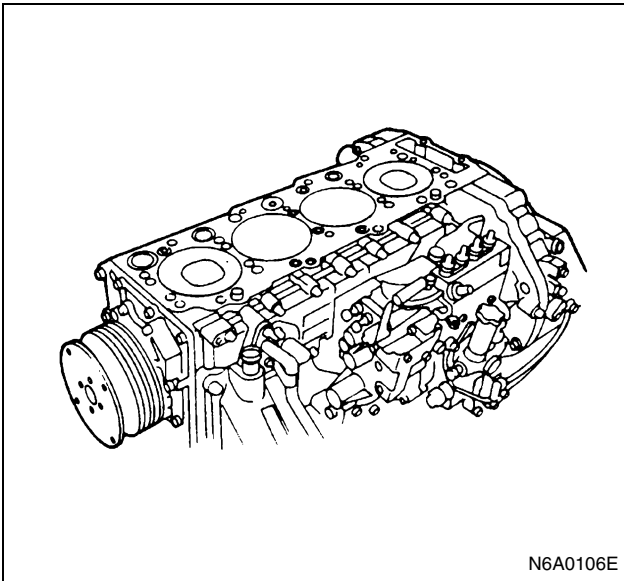
Do not reuse the cylinder head gasket.

Above works refer to "CYLINDER BLOCK" section in this manual.



1. Cylinder Head

- 1) Align the cylinder body dowels and the cylinder head dowel holes.
- 2) Carefully place the cylinder head on the cylinder head gasket.



- 3) Apply a coat of molybdenum disulfide grease to the M14 cylinder head bolt threads and setting faces and apply a coat of engine oil to the M10 cylinder head bolt threads and setting faces.
- 4) Use the angular tightening method to tighten the bolts (M14) to the specified torque in three steps following the numerical order shown in the illustration.

Tighten:

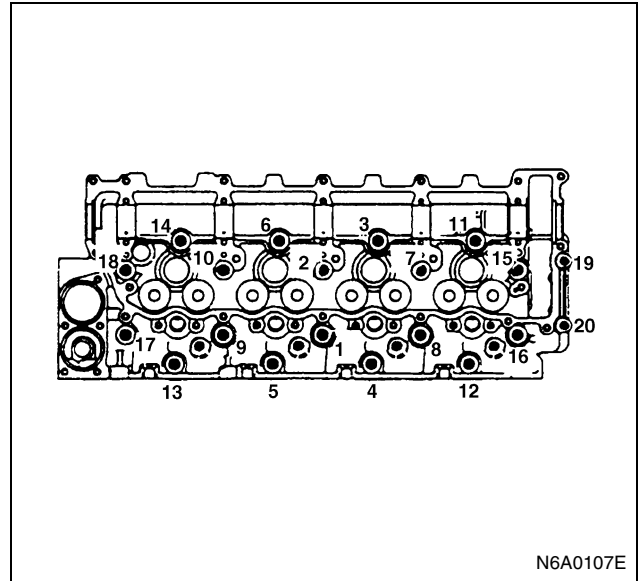
Cylinder head bolt (M14: (1) — (18)) to

- 1st step: 98 N·m (10 kg·m / 72 lb·ft)
- 2nd step: 147 N·m (15 kg·m / 108 lb·ft)
- 3rd step: 30 — 60°

- 5) Tighten the cylinder head to the flywheel housing bolts (M10) to the specified torque.

Tighten:

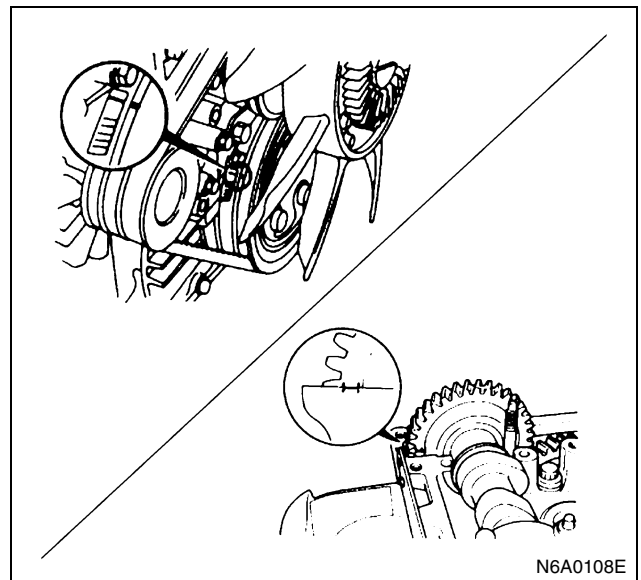
Cylinder head bolt to (M10: (19) — (20)) to 38 N·m (3.9 kg·m / 28 lb·ft)



2. Camshaft Bearing Lower

3. Camshaft Assembly

- 1) Turn the crankshaft in the direction of normal rotation until the timing mark on the crankshaft damper pulley is aligned with the TDC notched line. (Confirm that the No. 1 cylinder piston comes to the compression top dead center.)

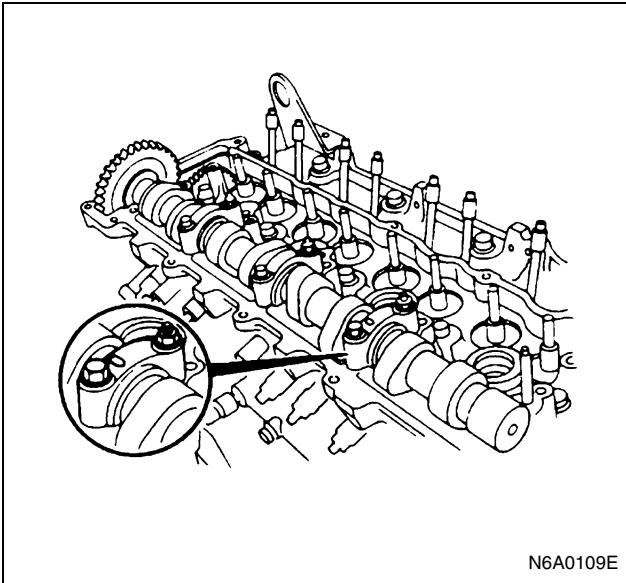


- 2) Apply engine oil to the camshaft journal and the camshaft bearing surfaces before installation.
- 3) Carefully align the camshaft gear "I" mark and the cylinder head upper face shown in the illustration.

4. Camshaft Bearing Upper

5. Camshaft Bearing Cap

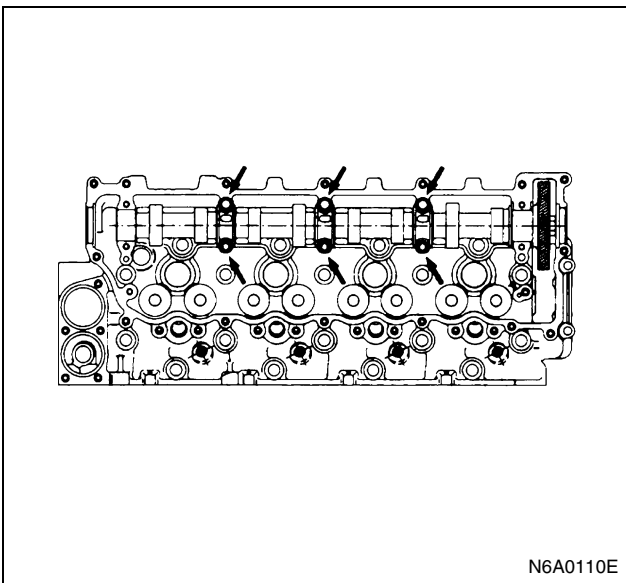
- 1) Install the bearing caps with the bearing cap head mark (arrow) facing forward.



- 2) Apply a coat of engine oil to the bearing cap bolt and stud threads.
- 3) Tighten the bearing cap bolts and studs to the specified torque.

Tighten:

Camshaft bearing cap nut and bolt to 27 N·m (2.8 kg·m / 20 lb·ft)

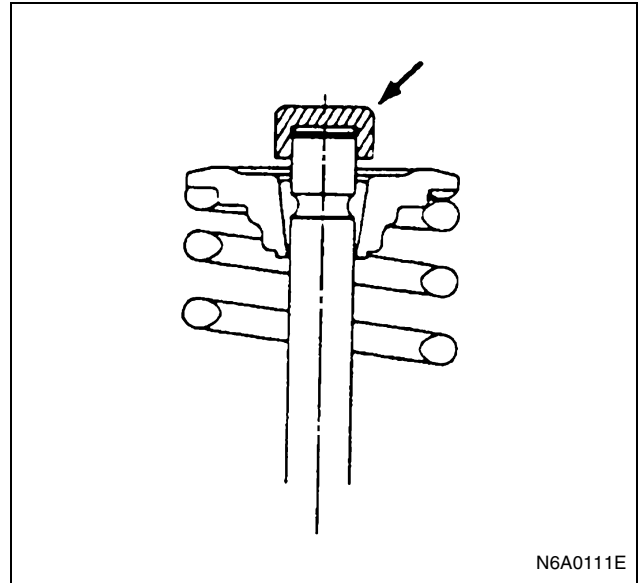


6. Valve Cap

Apply engine oil to the inside of the valve caps and install them to the valve stem end.

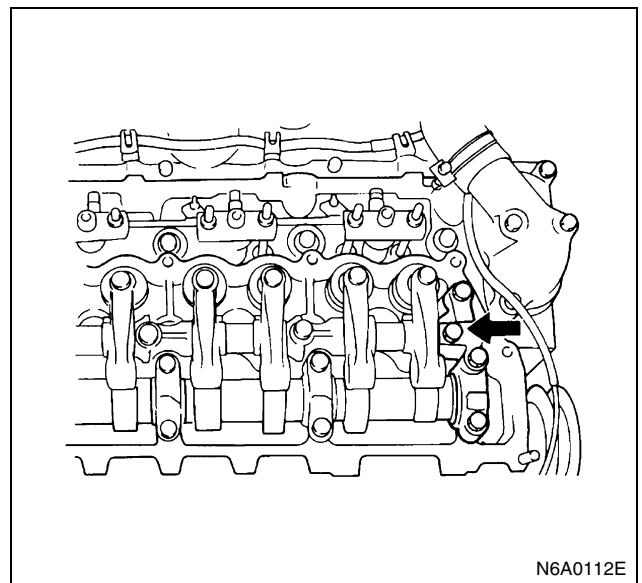
Caution:

Take sufficient care not to let valve caps fall into the gear.



7. Rocker Arm Shaft Assembly

- 1) Temporarily tighten the bolts marked with the arrow in the illustration.

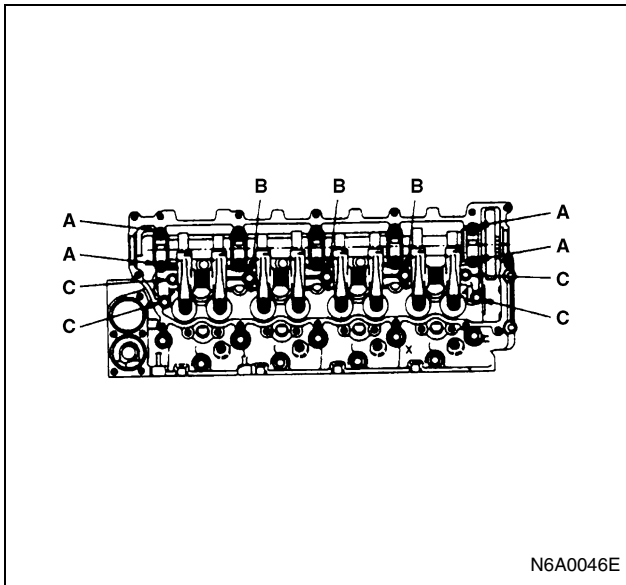


- 2) Loosen the rocker arm adjust screws and apply engine oil to the rocker arm roller portions.
- 3) Install the rocker arm assembly on the cylinder head.
- 4) Tighten the rocker arm shaft bracket nuts and bolts to the specified torque in numerical order a little at a time as shown in the illustration.

Tighten:

Rocker arm shaft bracket nut and bolt to

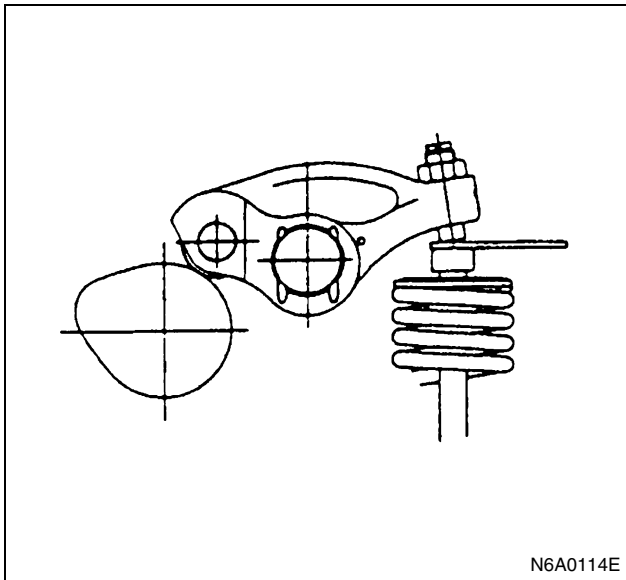
- Nut (A): 27 N·m (2.8 kg·m / 20 lb·ft)
- Bolt (B): 56 N·m (5.7 kg·m / 41 lb·ft)
- Bolt (C): 27 N·m (2.8 kg·m / 20 lb·ft)



- 5) Apply engine oil to the threaded portion of the nuts marked with "A" and the bolts with "B" shown in the illustration left, and tighten them to the specified torque.
Adjust the valve clearance.

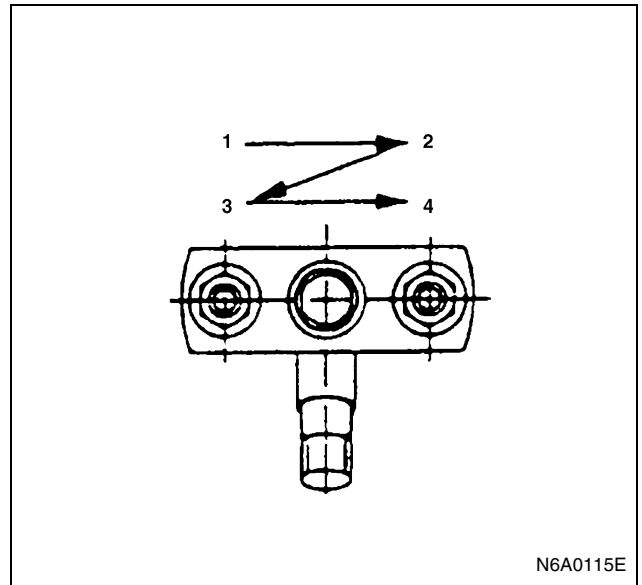
Valve Clearance		mm (in)
At cold		0.4 (0.016)

Above works refer to "SERVICING" "VALVE CLEARANCE ADJUSTMENT" previously section in this manual.



8. Injection Nozzle Holder Assembly
Tighten the nozzle holder flange nuts to the specified torque in the numerical order shown in the illustration.

Tighten:
Nozzle holder flange nut to 19 N·m (1.9 kg·m / 14 lb·ft)



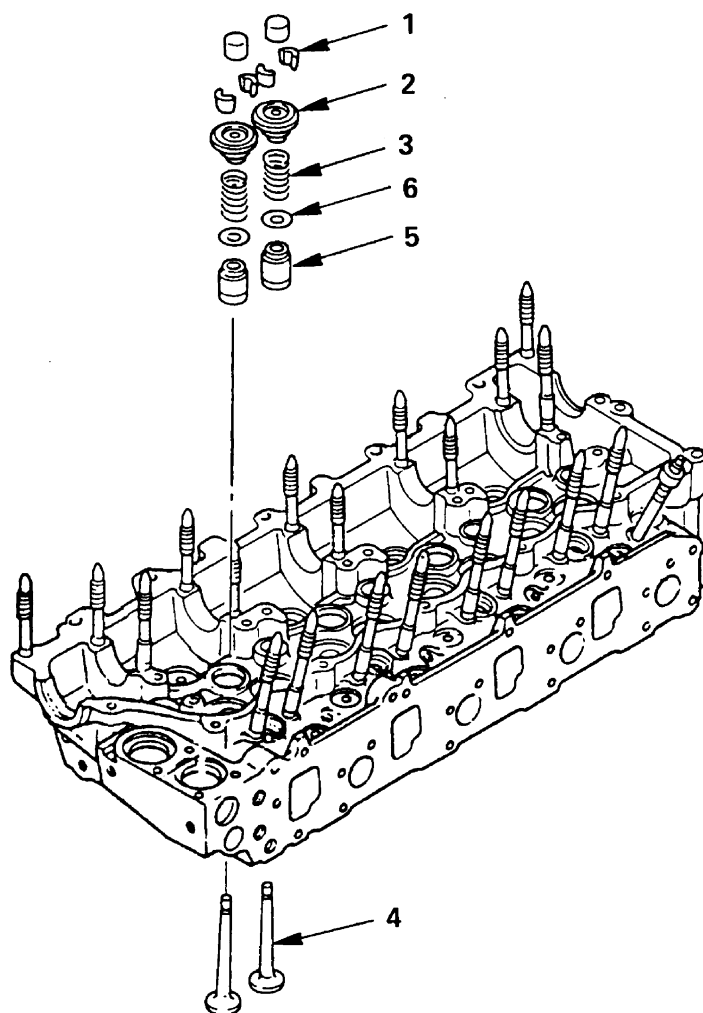
9. Glow Plug

Tighten:
Glow Plug to 23 N·m (2.3 kg·m / 17 lb·ft)

10. Glow Plug Connector

VALVE SPRING, VALVE GUIDE OIL SEAL, VALVE, VALVE GUIDE

Component



N6A0116E

Legend

- | | |
|----------------------|-----------------------------|
| 1. Split collar | 4. Intake and exhaust valve |
| 2. Spring upper seat | 5. Valve guide seal |
| 3. Valve spring | 6. Spring lower seat |

Disassembly

Preparation

- Remove all the parts only with the cylinder head assembly left.
(Above works refer to "CYLINDER HEAD GASKET" section 6A3 in this manual.)

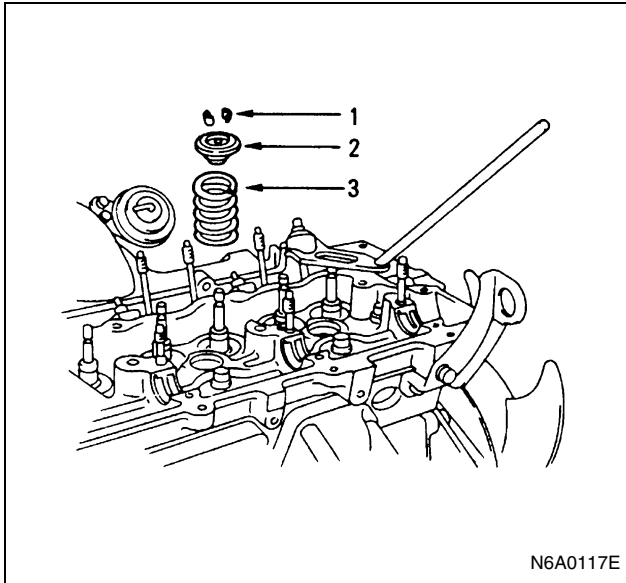
1. Cotter Collar

- Place the cylinder head on a flat wooden surface.
- Use the valve spring compressor to remove the cotter collar.

Do not allow the valve to fall from the cylinder head.

Valve Spring Compressor: 5-8840-2228-0

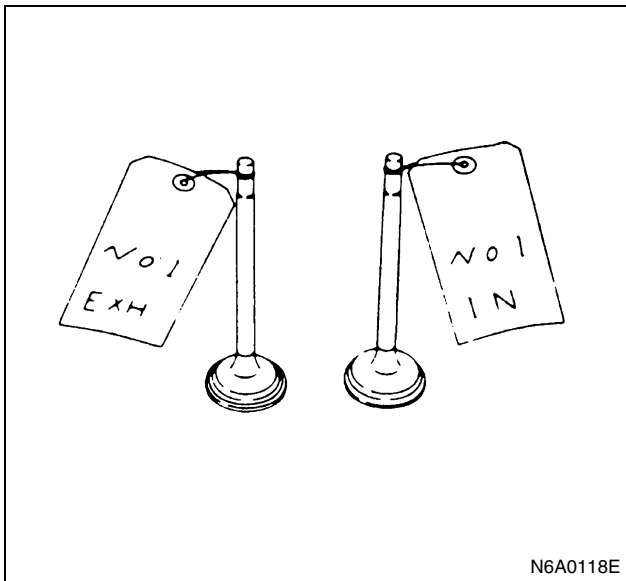
- Spring Upper Seat
- Valve Spring



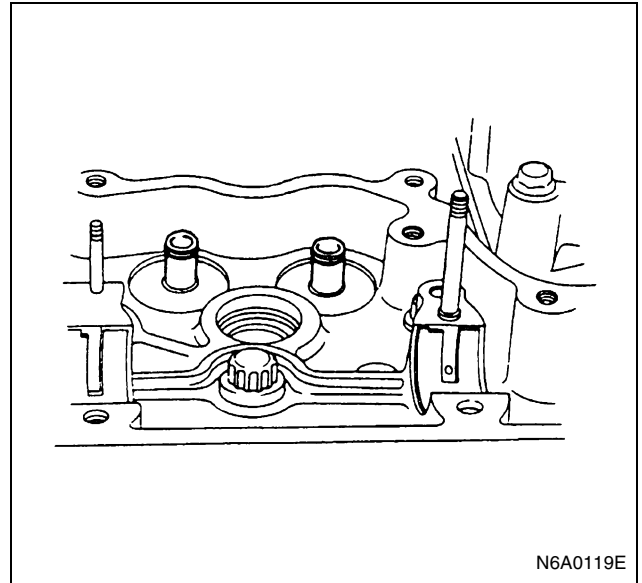
4. Intake and Exhaust Valve

If the intake and exhaust valves are to be reinstalled, mark their installation positions by tagging each valve with the cylinder number from which it was removed.

If the intake and exhaust valves are to be replaced, the valve guides must also be replaced.



5. Valve Guide Seal
6. Spring Lower Seat



Inspection and Repair

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

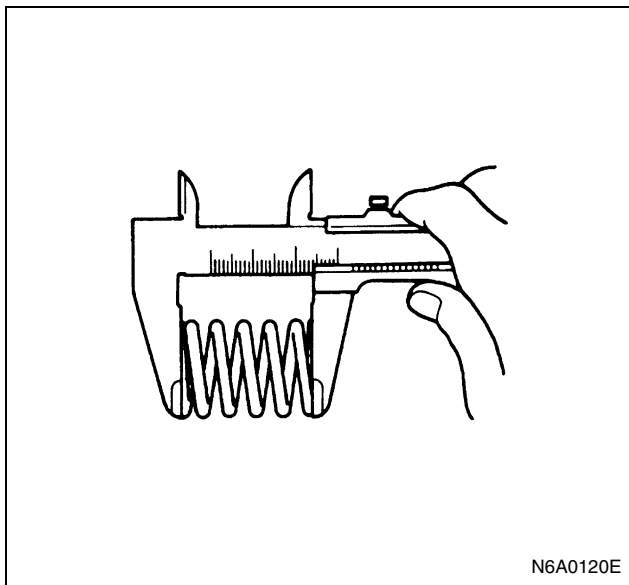
Valve Spring Free Height

Use a vernier caliper to measure the valve spring free height.

If the measured valve is less than the specified limit, the valve spring must be replaced.

Valve Spring Free Height		mm (in)
4HF1: 4HF1-2: 4HG1: 4HG1-T		
Nominal Size	Limit	
62.5 (2.46)	59.4 (2.34)	

4HE1-TC:			mm (in)
	Nominal size	Limit	
Intake Inner	53.2 (2.094)	50.1 (1.972)	
Intake Outer	55.6 (2.189)	52.5 (2.067)	
Exhaust Inner	58.6 (2.307)	55.5 (2.185)	
Exhaust Outer	62.0 (2.441)	58.9 (2.319)	



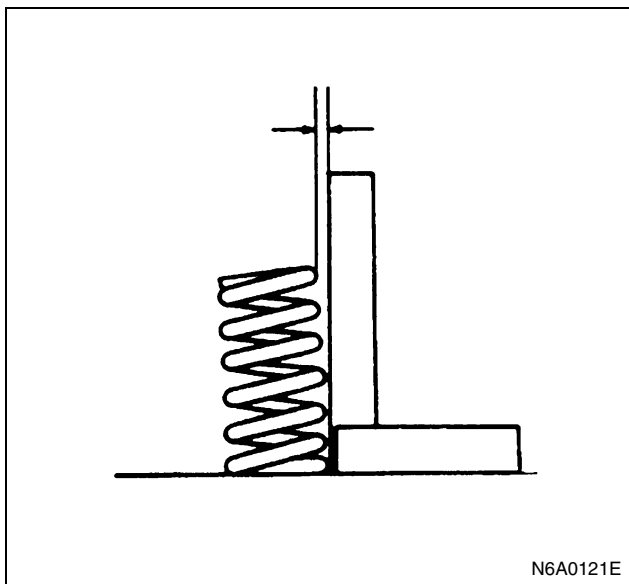
N6A0120E

Valve Spring Squareness

Use a surface plate and a square to measure the valve spring squareness.

If the measured value exceeds the specified limit, the valve spring must be replaced.

Valve Spring Squareness		mm (in)
Limit		1.0 (0.04)



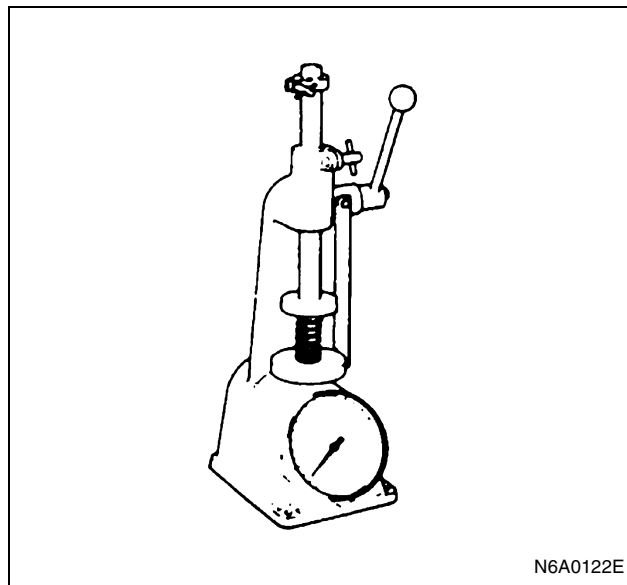
N6A0121E

Valve Spring Tension

Use spring tester to measure the valve spring tension.

If the measured valve is less than the specified limit, the valve spring must be replaced.

Valve Spring Tension			N (kg/lb)
Set Length mm (in)	Standard	Limit	
47.0 (1.85)	414 — 477 (42.2 — 48.6/93 — 107)	401 (40.9/98)	



N6A0122E

Valve Guide

Caution:

Taking care not to damage the valve seat contact surface, when removing carbon adhering to the valve head. Carefully inspect the valve stem for scratching or abnormal wear. If these conditions are present, the valve and the valve guide must be replaced as a set.

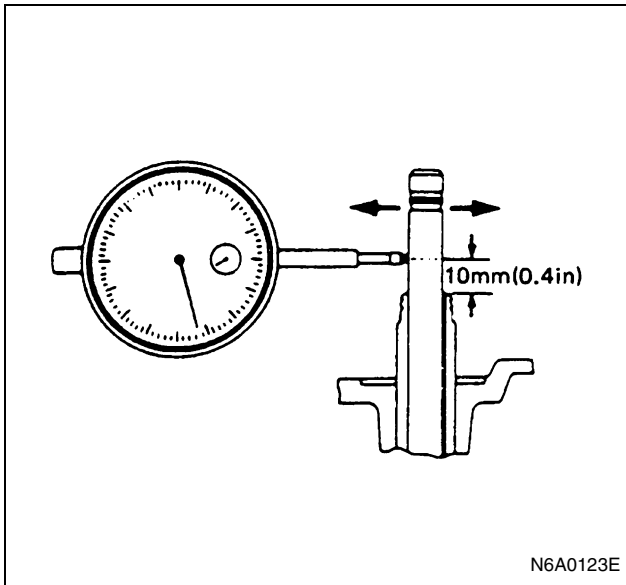
Valve Stem and Valve Guide Clearance (Measuring Method-I)

1. Set the dial indicator to the valve stem measuring point.
2. Move the valve stem end from side to side. Read the dial indicator.

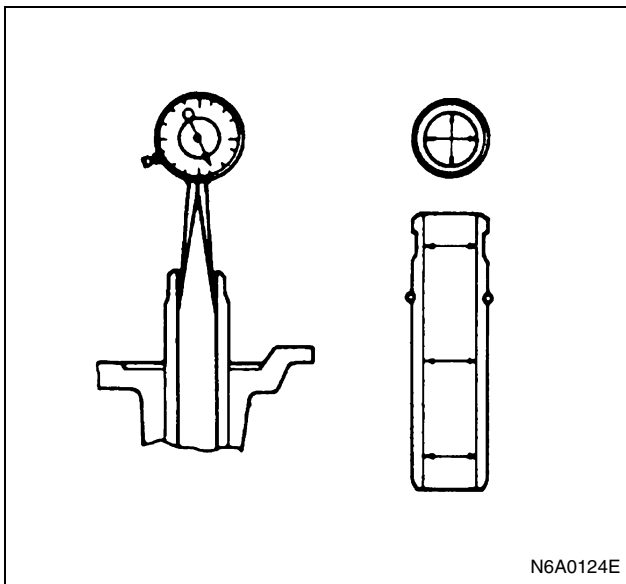
Note the total indicator reading.

If the measured values exceed the specified limit, the valve and the valve guide must be replaced as a set.

Total Dial Indicator Reading (Valve Stem and Valve Guide Clearance)			mm (in)
Valve	Standard	Limit	
Intake Valve	0.038 — 0.071 (0.0015 — 0.0028)	0.20 (0.0079)	
Exhaust Valve	0.064 — 0.096 (0.0025 — 0.0038)	0.25 (0.0098)	

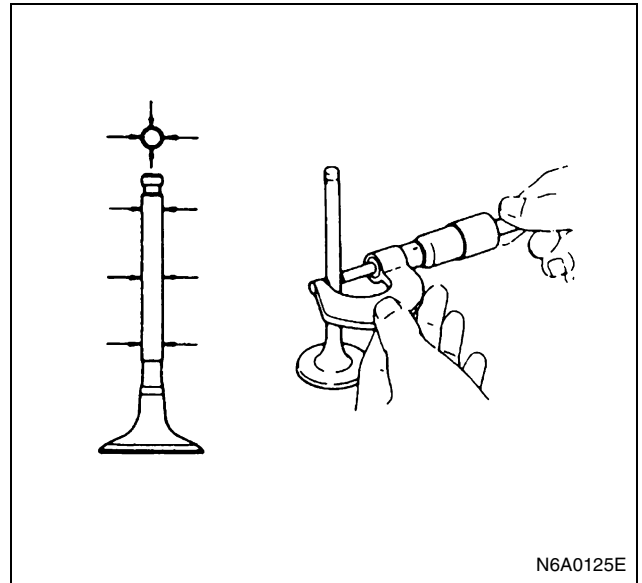
**(Measuring Method-II)**

1. Measure the valve stem outside diameter. Refer to the "Valve Stem Outside Diameter".
2. Use a caliper calibrator or a telescoping gauge to measure the valve guide inside diameter.
3. Calculate the clearance between the valve guide inside diameter and the valve stem outside diameter. If the clearance exceeds the specified limit, the valve and the valve guide must be replaced as a set.

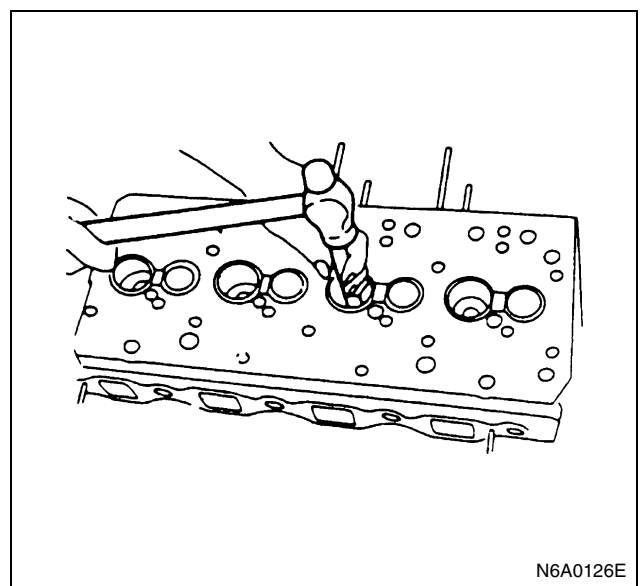
**Valve Stem Outside Diameter**

Measure the valve stem diameter at three points. If the measured valve is less than the specified limit, the valve and the valve guide must be replaced as a set.

Valve Stem Outside Diameter		mm (in)
Valve	Standard	Limit
Intake Valve	8.946 — 8.962 (0.3522 — 0.3528)	8.88 (0.350)
Exhaust Valve	8.921 — 8.936 (0.3512 — 0.3529)	8.80 (0.346)

**Valve Guide Replacement****Valve Guide Removal**

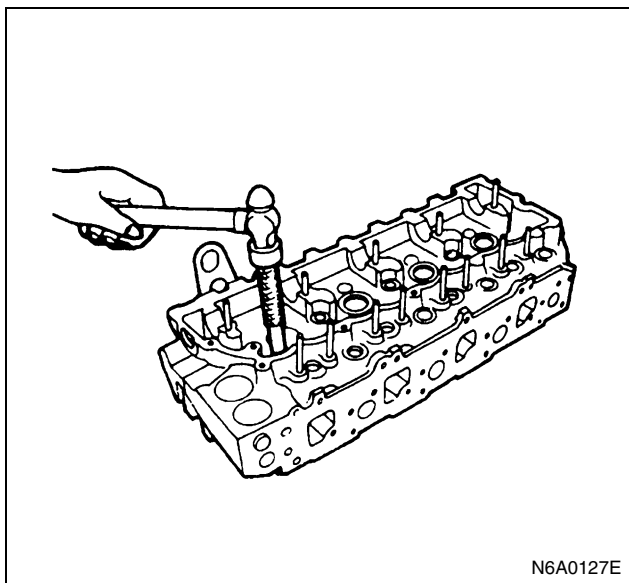
Use a hammer and the valve guide replacer to drive out the valve guide from the cylinder head lower face. Valve Guide Replacer: 5-8840-2227-0

**Valve Guide Installation**

1. Apply engine oil to the valve guide outer circumference.
2. Attach the valve guide installer to the valve guide. Valve Guide Replacer: 5-8840-2227-0

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- Use a hammer to drive the valve guide into position from the cylinder head upper face.

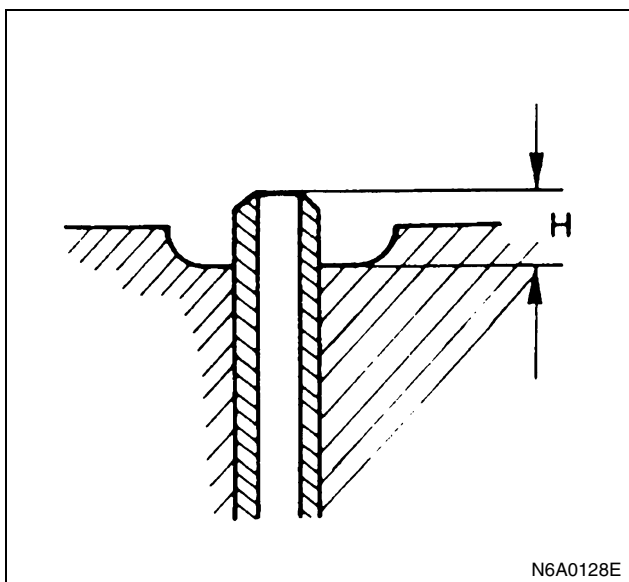


- Measure the height (H) of the valve guide upper end from the cylinder head upper face.

Valve Guide Upper End Height (H)	mm (in)
14.1 ± 0.2 (0.555 ± 0.008)	

Notice:

If the valve guide has been removed, both the valve and the valve guide must be replaced as a set.

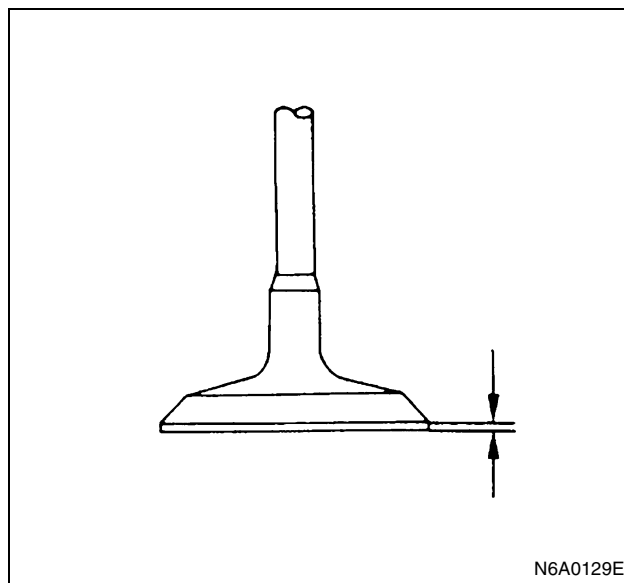


Valve and Valve Seat Insert

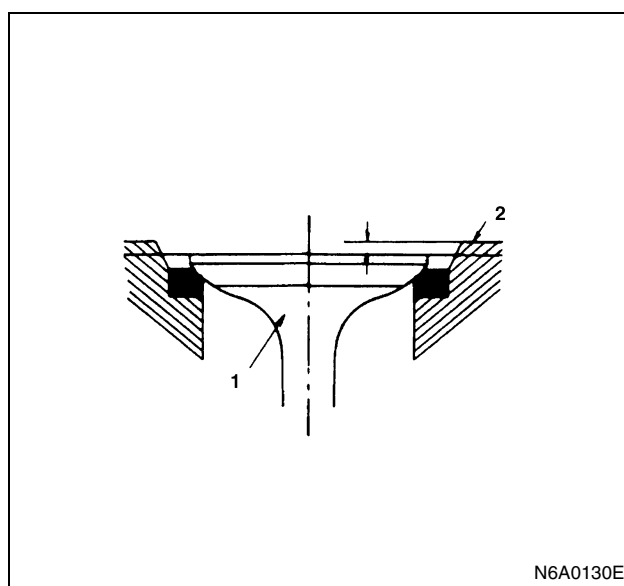
Valve Thickness and Depression

- Measure the valve thickness.
If the measured value is less than the specified limit, the valve and the valve seat insert must be replaced as a set.

Intake and Exhaust Valve Thickness		mm (in)
Valve	Nominal Size	Limit
Inlet	1.8 (0.071)	1.3 (0.051)
Exhaust	1.75 (0.069)	1.3 (0.051)



- Install the new valve (1) to the cylinder head (2).



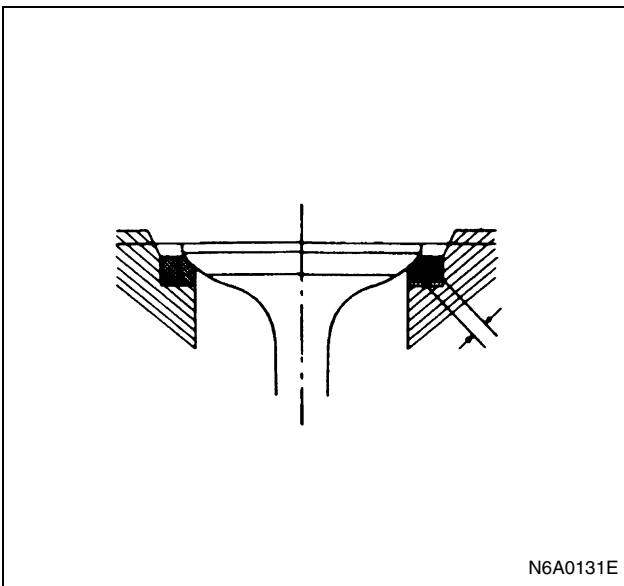
- Use a depth gauge or a straight edge with steel rule to measure the valve depression from the cylinder head lower surface.
If the measured value exceeds the specified limit, the valve seat insert and/or the valve must be replaced.

Intake and Exhaust Valve Depression		mm (in)
Standard	Limit	
0.7 — 1.2 (0.028 — 0.047)	2.5 (0.098)	

Valve Contact Width

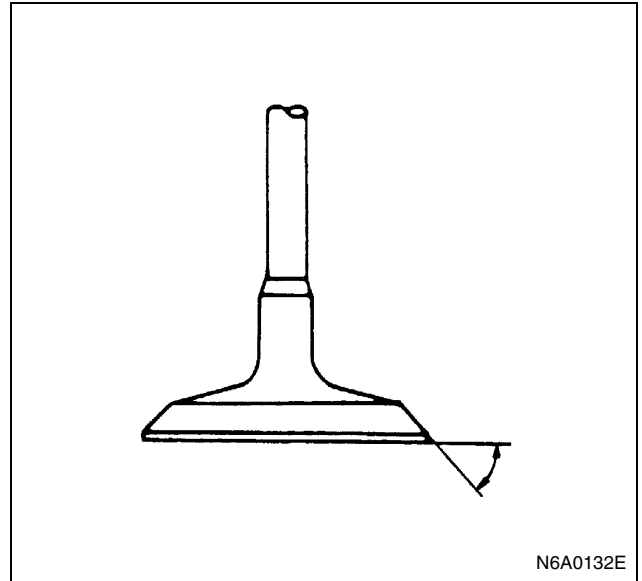
1. Check the valve contact faces for roughness and unevenness.
Make smooth the valve contact surfaces.
2. Measure the valve contact width.
If the measured value exceeds the specified limit, the valve seat insert must be corrected or replaced.

Valve Contact Width		mm (in)
Valve	Nominal Size	Limit
Intake	2.5 (0.098)	3.0 (0.118)
Exhaust	2.0 (0.079)	2.5 (0.098)

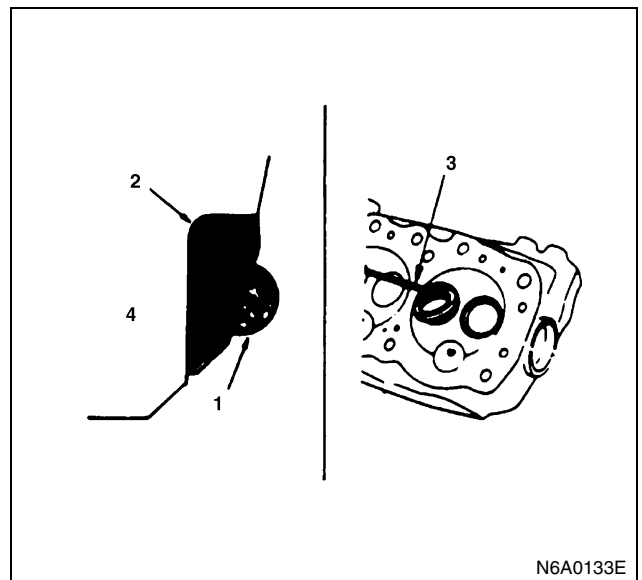
**Contact Surface Angle on Valve Seat on Valve**

1. Measure contact surface angle on valve seat.
2. If the measured value exceeds the limit, replace valve, valve guide and valve seat as a set.

Standard	Degrees
45°	

**Valve Seat Insert Replacement****Valve Seat Insert Removal**

1. Arc weld the entire inside circumference (1) of the valve seat insert (2).
2. Allow the valve seat insert to cool for a few minutes. This will invite contraction and make removal of the valve seat insert easier.
3. Use a screwdriver (3) to pry the valve seat insert free. Take care not to damage the cylinder head (4).
4. Carefully remove carbon and other foreign material from the cylinder head insert bore.

**Valve Seat Insert Installation**

1. Carefully place the attachment (1) (having a smaller outside diameter than the valve seat insert) on the valve seat insert (2).

Notice:

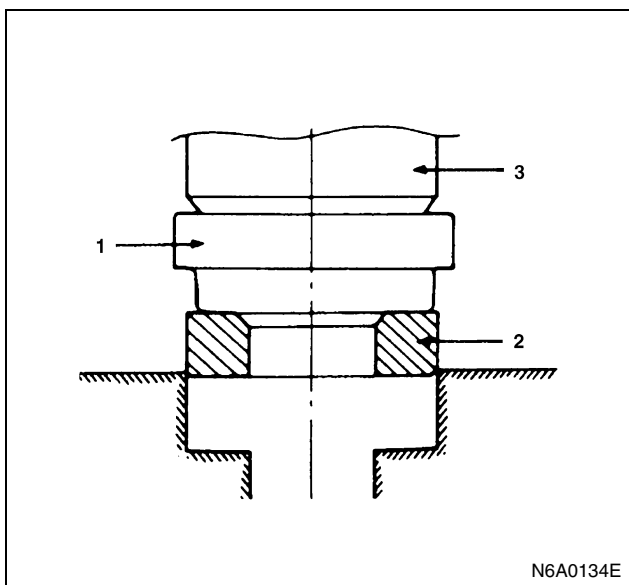
The smooth side of the attachment must contact the valve seat insert.

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2. Use a bench press (3) to gradually apply pressure to the attachment and press the valve seat insert into place.

Caution:

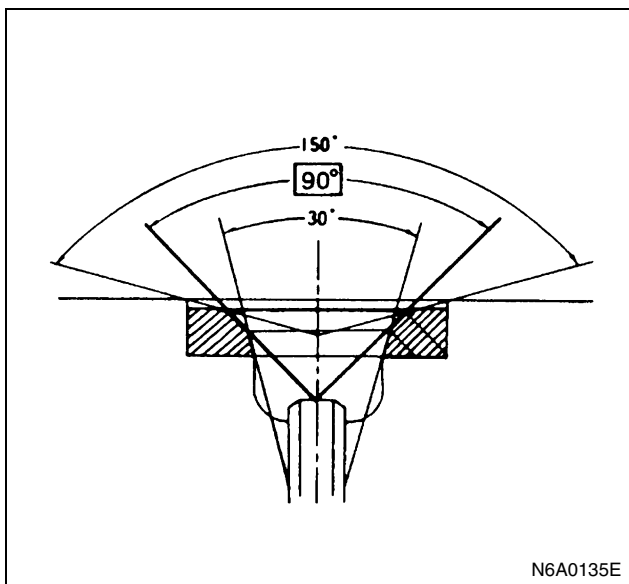
Do not apply an excessive amount of pressure with the bench press. Damage to the valve seat insert will result.



3. The valve should be lapped before final assembly to ensure a good valve seal. Above works refer to "Valve Seat Insert Correction" section in this manual.

Valve Seat Insert Correction

1. Remove the carbon from the valve seat insert surface.
2. Use a valve cutter (15°, 45°, and 75° blades) to minimize scratches and other rough areas. This will bring the contact width back to the standard value. Remove only the scratches and rough areas. Do not cut away too much. Take care not to cut away unblemished areas of the valve seat surface.

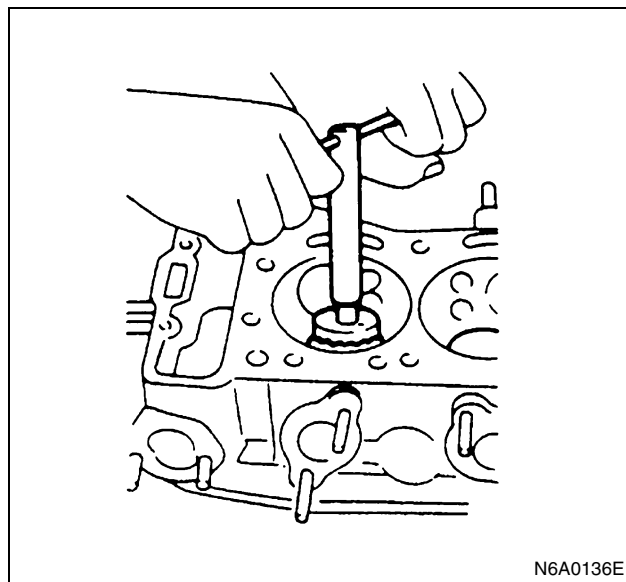


Valve Seat Angle	Degrees
	45°

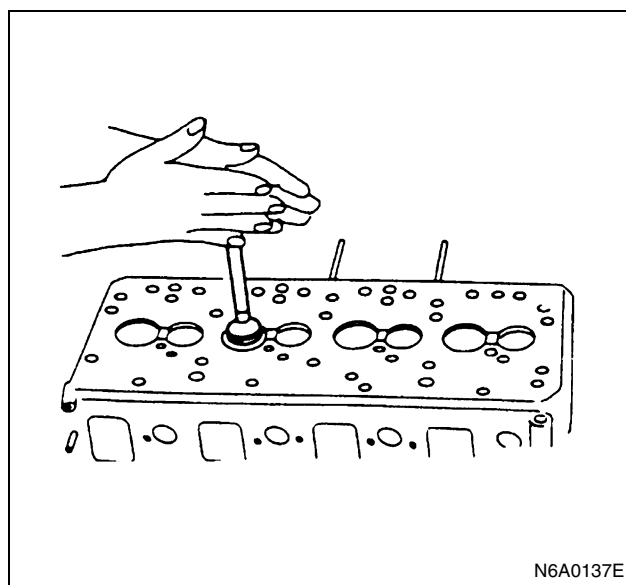
Notice:

Use an adjustable valve cutter pilot.

Do not allow the valve cutter pilot to wobble inside the valve guide.



3. Apply abrasive compound to the valve seat insert surface.
4. Insert the valve into the valve guide.
5. Turn the valve while tapping it to fit the valve seat insert.



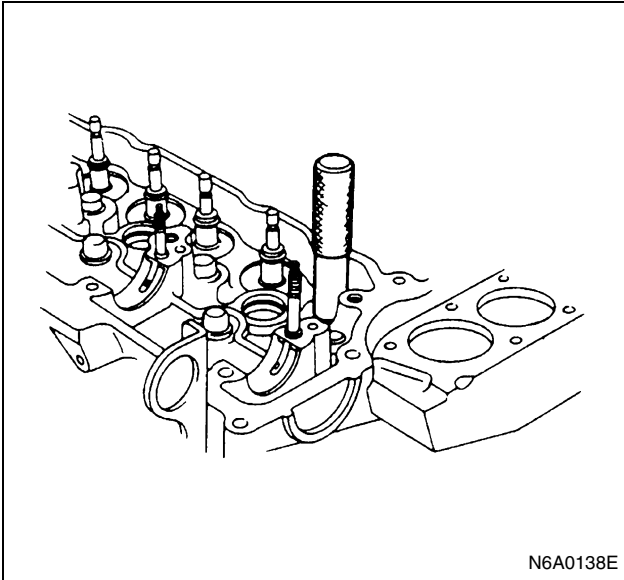
6. Check to see if the valve contact width is correct.
7. Check to see if the valve seat insert surface is in contact with the entire circumference of the valve.

Reassembly

1. Spring Lower Seat

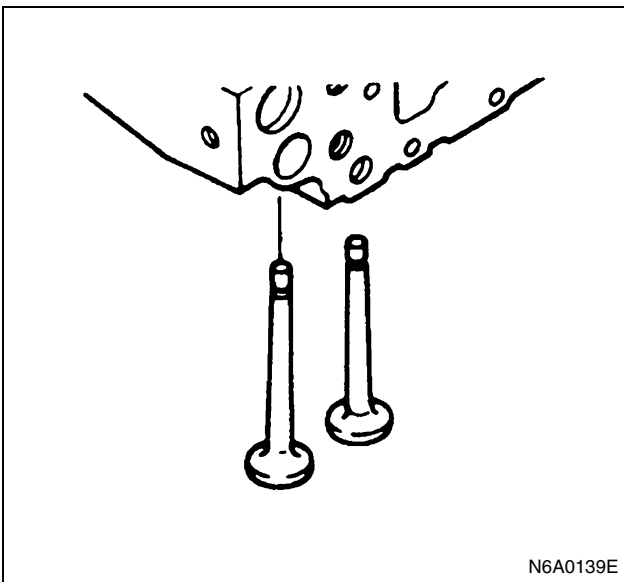
2. Valve Guide Seal

- 1) Apply a coat of engine oil to the valve guide seal inner face.
- 2) Use a valve guide seal installer to install the valve guide seal to the valve guide
Valve Guide Seal Installer: 8-9439-6815-0



3. Intake and Exhaust Valve

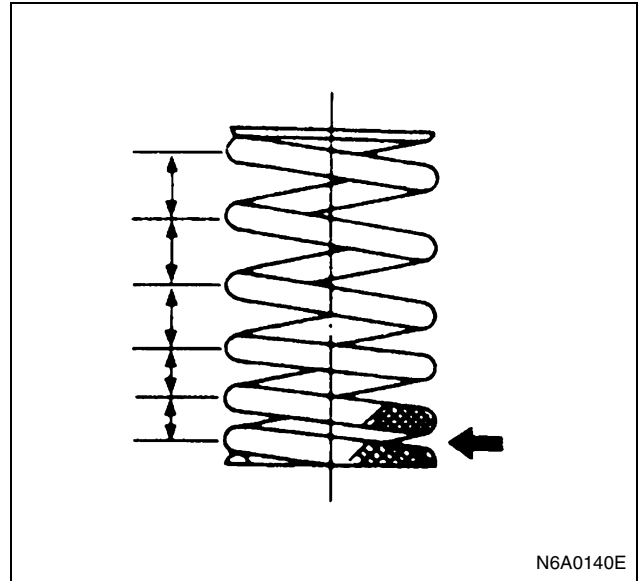
- 1) Apply a coat of engine oil to each valve stem before installation.
- 2) Install the intake and exhaust valve.



- 3) Turn the cylinder head up to install the valve spring. Take care not to allow the installed valves to fall free.

4. Valve Spring

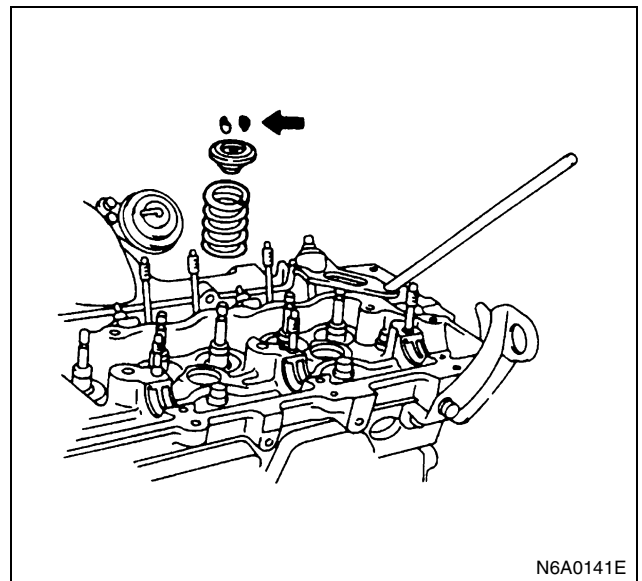
Install the valve spring with its fine pitched (or painted) end side down.



5. Spring Upper Seat

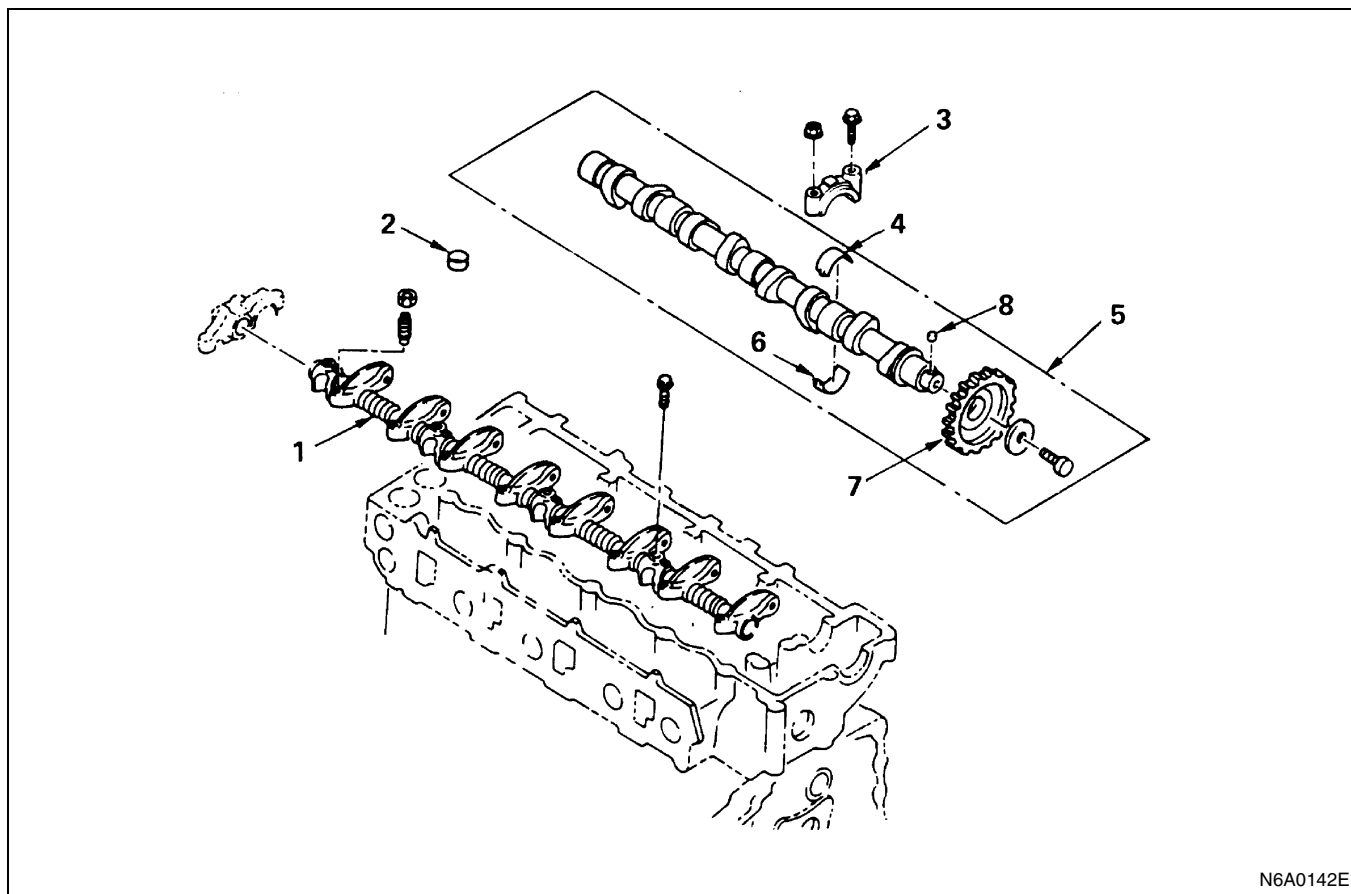
6. Cotter Collar

- 1) Use the valve spring compressor to push the valve spring into position.
Valve Spring Compressor: 5-8840-2228-0
- 2) Install the cotter collar to the valve stem.
- 3) Set the cotter collar by tapping around the head of the collar with a rubber hammer.



CAMSHAFT

Component



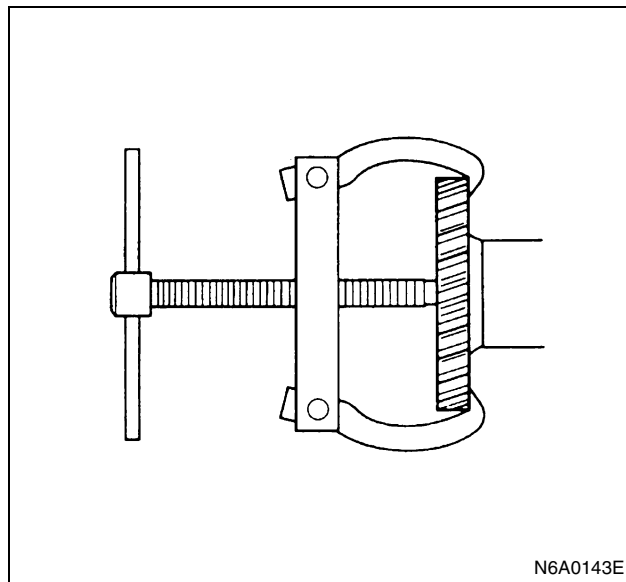
N6A0142E

Legend

- | | |
|------------------------------|---------------------------|
| 1. Rocker arm shaft assembly | 5. Camshaft assembly |
| 2. Valve cap | 6. Camshaft bearing lower |
| 3. Camshaft bearing cap | 7. Camshaft gear |
| 4. Camshaft bearing upper | 8. Key |

Disassembly

1. Rocker Arm Shaft Assembly
2. Valve Cap
3. Camshaft Bearing Cap
4. Camshaft Bearing Upper
5. Camshaft Assembly
6. Camshaft Bearing Lower
Above works refer to "CYLINDER HEAD" section in this manual.
7. Camshaft Gear
Use the universal puller to pull out the camshaft gear.
Universal puller: 5-8840-2027-0/5-8840-0086-0
8. Key



N6A0143E

Inspection and Repair

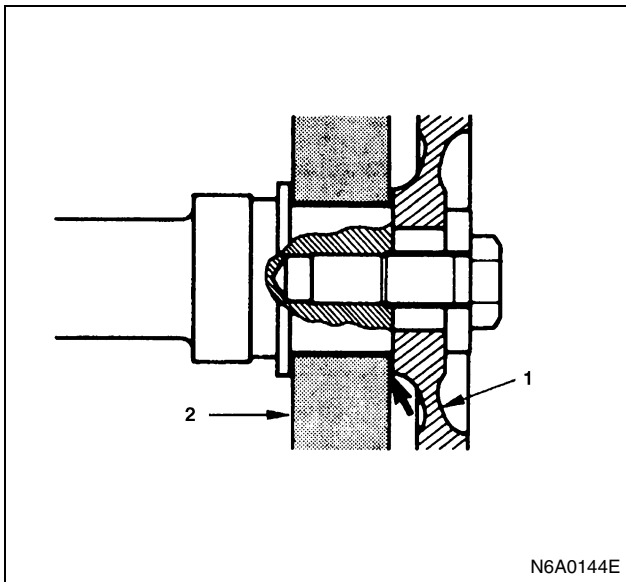
Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

Camshaft End Play

Use a thickness gauge to measure the clearance between the camshaft gear (1) and the camshaft bracket (2).

If the measured value exceeds the specified limit, the camshaft gear or the camshaft must be replaced.

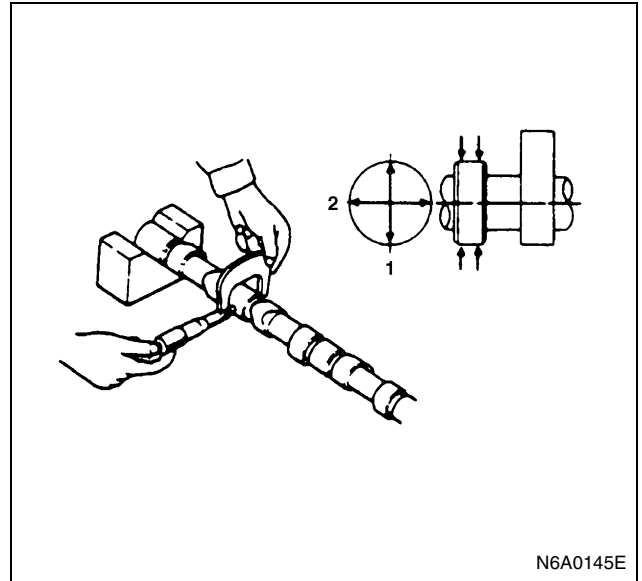
Camshaft End Play		mm (in)
Standard	Limit	
0.085 — 0.205 (0.0033 — 0.0081)	0.25 (0.0098)	



Camshaft Journal Diameter

Use a micrometer to measure each camshaft journal diameter in two directions ((1) and (2)). If the measured value is less than the specified limit, the camshaft must be replaced.

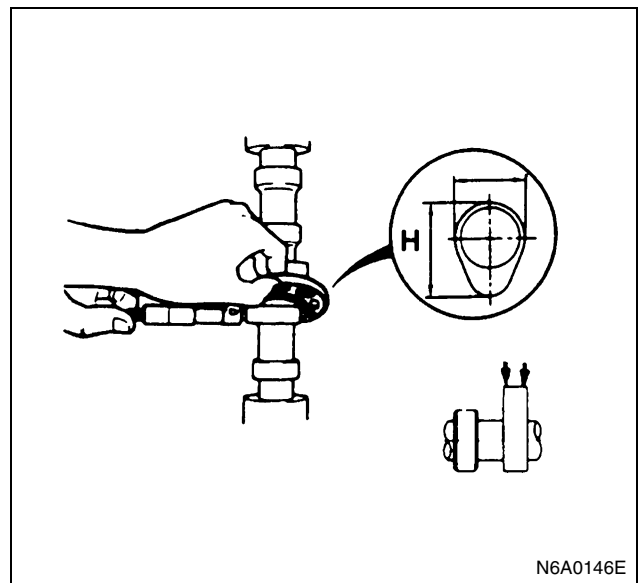
Camshaft Journal Diameter		mm (in)
Standard	Limit	
39.950 — 39.975 (1.5728 — 1.5738)	39.850 (1.569)	



Cam Height

Measure the cam height "H" with a micrometer. If the measured value is less than the specified limit, the camshaft must be replaced.

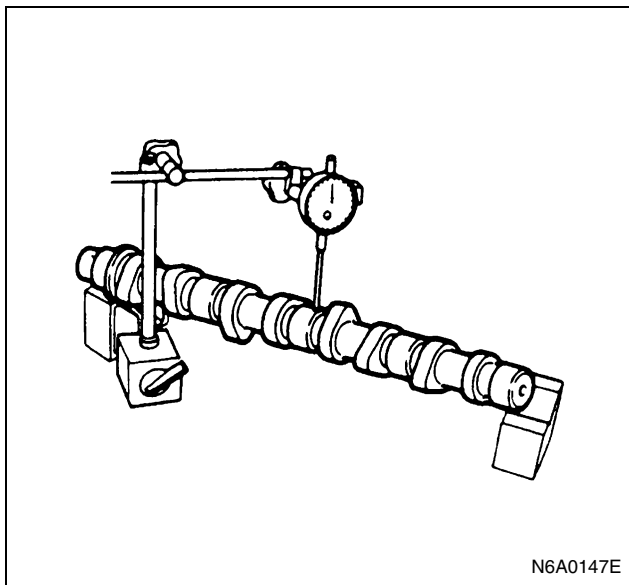
Cam Height "H"			mm (in)
Engine model	Standard	Limit	
Except 4HE1-TC	52.8 (2.078)	51.8 (2.039)	
4HE1-TC	53.6 (2.110)	52.6 (2.071)	



Camshaft Run-Out

1. Mount the camshaft on V-blocks.
2. Measure the run-out with a dial indicator.
If the measured value exceeds the specified limit, the camshaft must be replaced.

Camshaft Run-Out		mm (in)
Limit		0.05 (0.002)



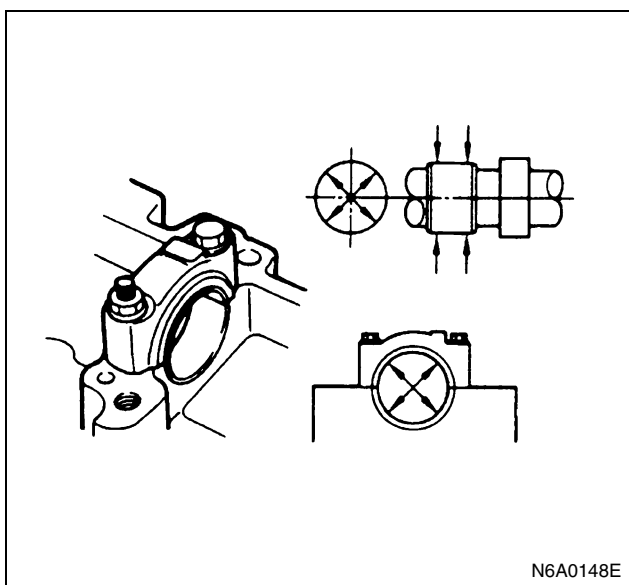
Camshaft and Camshaft Bearing Clearance

Use an inside dial indicator to measure the camshaft bearing inside diameter.

Camshaft Bearing Inside Diameter		mm (in)
Standard	40.000 — 40.037 (1.5748 — 1.5763)	

If the clearance between the camshaft bearing inside diameter and the journal exceeds the specified limit, the camshaft bearing must be replaced.

Camshaft Bearing Clearance		mm (in)
Standard	Limit	
0.025 — 0.087 (0.00098 — 0.00343)	0.15 (0.0059)	

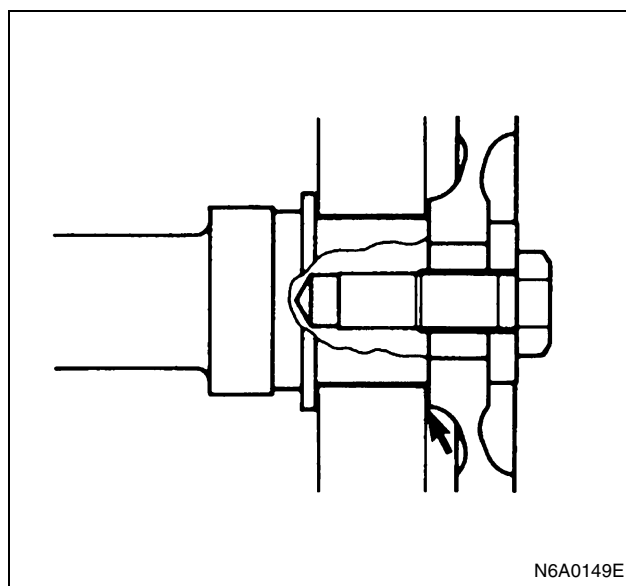


Reassembly

1. Key
2. Camshaft Gear
 - With the projection of the camshaft gear center boss turned to the camshaft side, set it to the knock pin and install the camshaft gear.

Tighten:

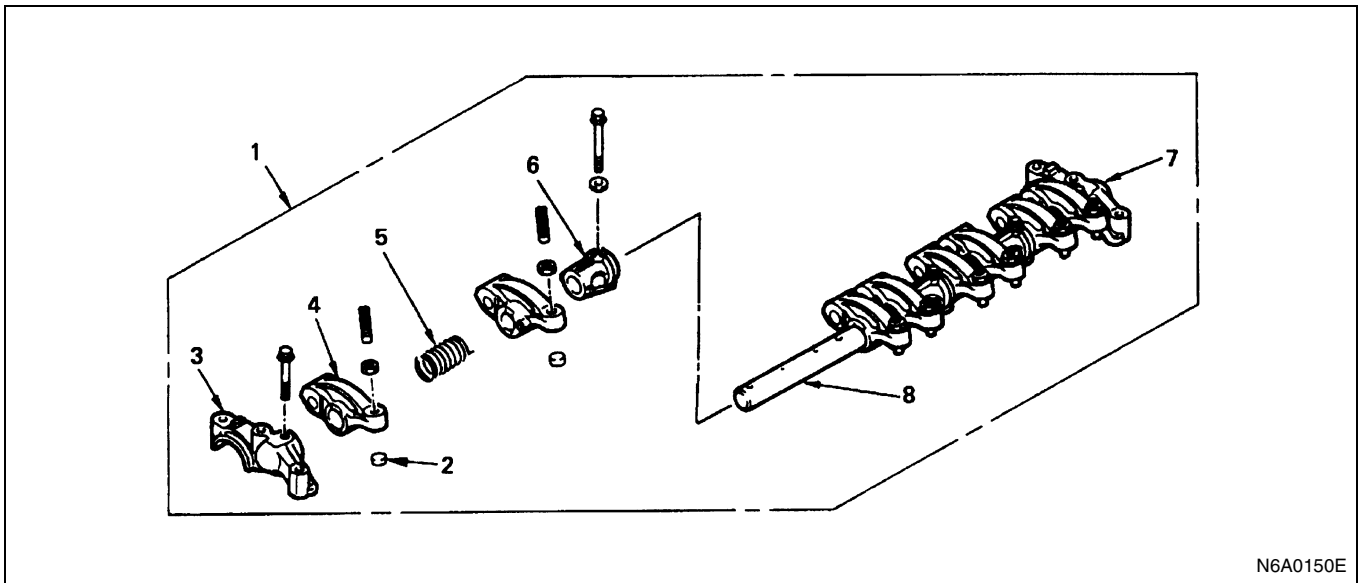
Camshaft gear bolt to 142 N·m (14.5 kg·m / 105 lb·ft)



3. Camshaft Bearing Lower
 4. Camshaft Assembly
 5. Camshaft Bearing Upper
 6. Camshaft Bearing Cap
 7. Valve Cap
 8. Rocker Arm Shaft Assembly
- Above works refer to "CYLINDER HEAD" section in this manual.

ROCKER ARM ASSEMBLY

Component



N6A0150E

Legend

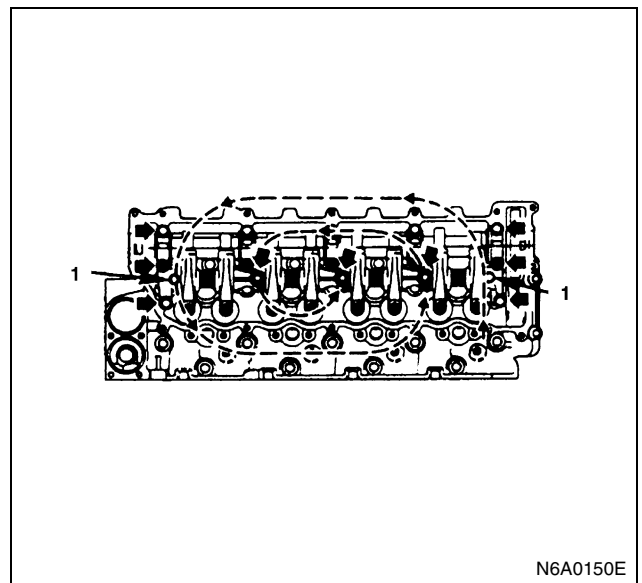
- | | |
|------------------------------|-----------------------|
| 1. Rocker arm shaft assembly | 5. Spring |
| 2. Valve cap | 6. Rocker arm bracket |
| 3. Camshaft bracket | 7. Camshaft bracket |
| 4. Rocker arm | 8. Rocker arm shaft |

Disassembly

1. Rocker Arm Shaft Assembly
 - 1) Loosen the rocker arm shaft bracket nuts and bolts in numerical order a little at a time and remove the rocker arm shaft assembly with the camshaft brackets.
 - 2) Leave the (1) indicated bolt unremoved on this occasion, since it is the rocker arm fixing bolt.

Caution:

Failure to loosen the rocker arm shaft bracket nuts and bolts in numerical order a little at a time will adversely affect the rocker arm shaft.



N6A0150E

2. Valve Cap

Caution:

Take sufficient care not to let the valve caps fall into the gear case or oil return hole.

3. Camshaft Bracket
4. Rocker Arm
5. Spring
6. Rocker Arm Bracket
7. Camshaft Bracket

8. Rocker Arm Shaft

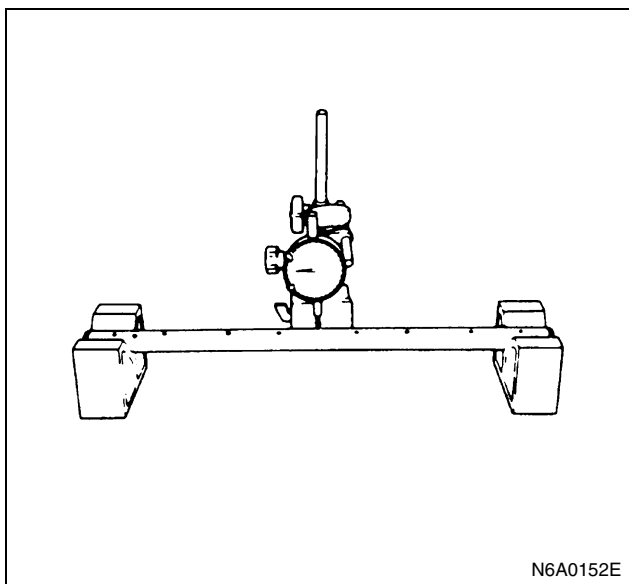
Inspection and Repair

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

Rocker Arm Shaft Run-Out

- 1) Place the rocker arm shaft on V-blocks.
- 2) Use a dial indicator to measure the rocker arm shaft central portion run-out.
If the run-out is very slight, correct the rocker arm shaft run-out with a bench press. The rocker arm must be at cold condition.
If the measured rocker arm shaft run-out exceeds the specified limit, the rocker arm shaft must be replaced.

Rocker Arm Shaft Run-Out		mm (in)
Limit		0.3 (0.012)



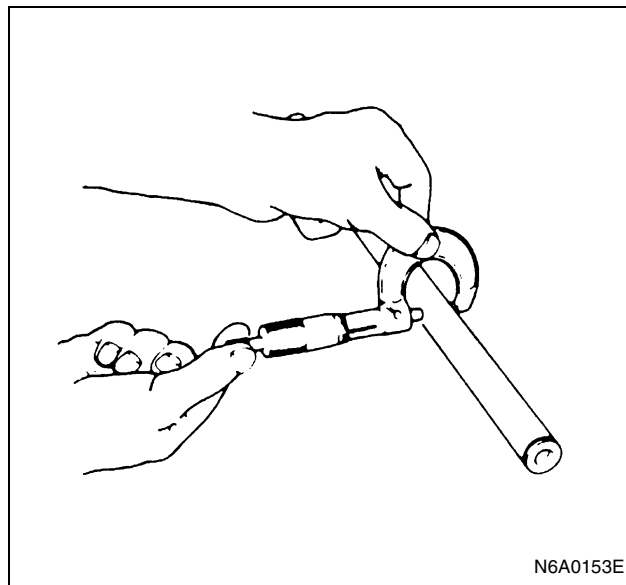
N6A0152E

Rocker Arm Shaft Outside Diameter

Use a micrometer to measure the rocker arm fitting portion outside diameter.

If the measured value is less than the specified limit, the rocker arm shaft must be replaced.

Rocker Arm Shaft Outside Diameter		mm (in)
Standard	Limit	
21.979 — 22.000 (0.8653 — 0.8661)		21.85 (0.8602)



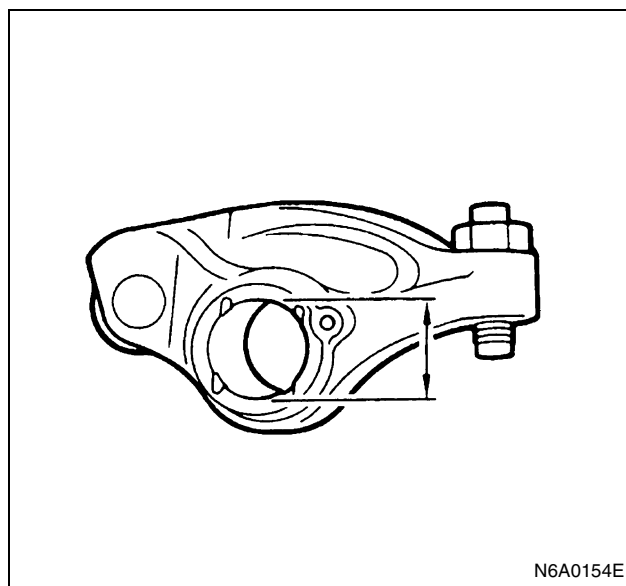
N6A0153E

Rocker Arm Bushing Inside Diameter

Use either a vernier caliper or a dial indicator to measure the rocker arm bushing inside diameter.

Rocker Arm Bushing Inside Diameter		mm (in)
Standard	Limit	
22.010 — 22.035 (0.8665 — 0.8675)		22.15 (0.8720)

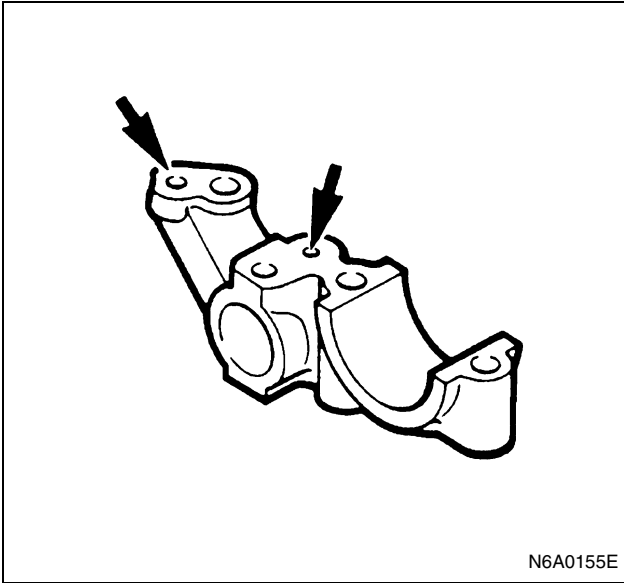
Rocker Arm and Rocker Arm Shaft Clearance		mm (in)
Standard	Limit	
0.010 — 0.056 (0.0004 — 0.0022)		0.2 (0.0079)



N6A0154E

Check to see if the rocker arm oil port is free of obstructions.

If necessary, use compressed air to clean the rocker arm oil port.



Legend

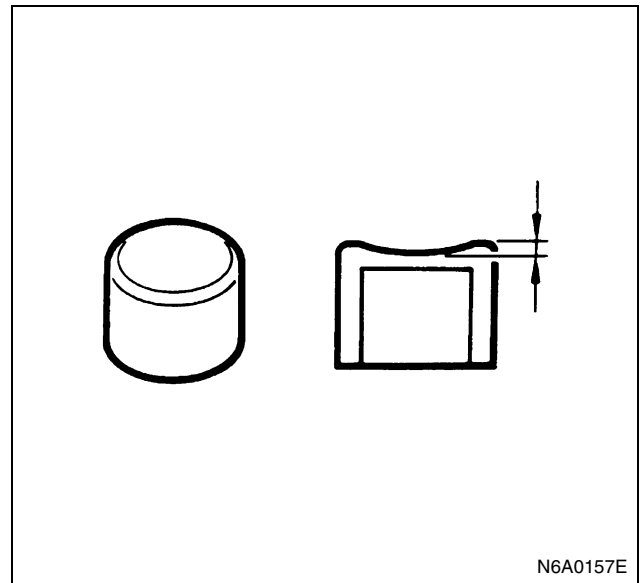
1. Roller
2. Depth gauge

Valve Cap Wear

Inspect the valve cap surface contacting the rocker arm using a dial gauge.

If wear exceeds the limit, replace the valve cap with a new one.

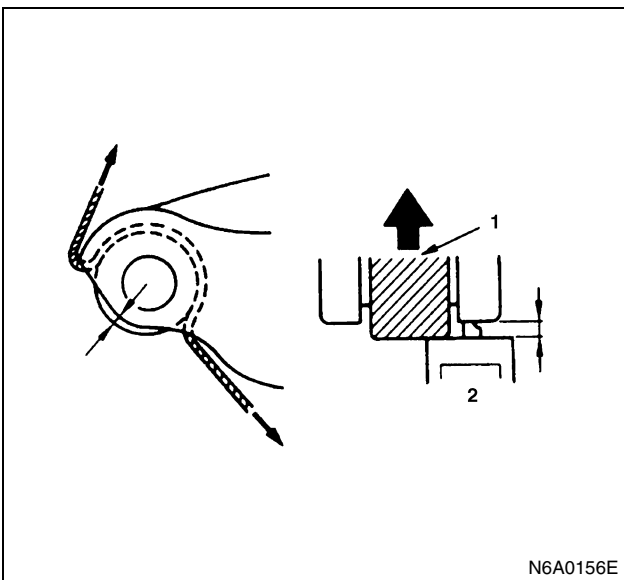
Valve Cap Worn		mm (in)
Limit		0.1 (0.004)



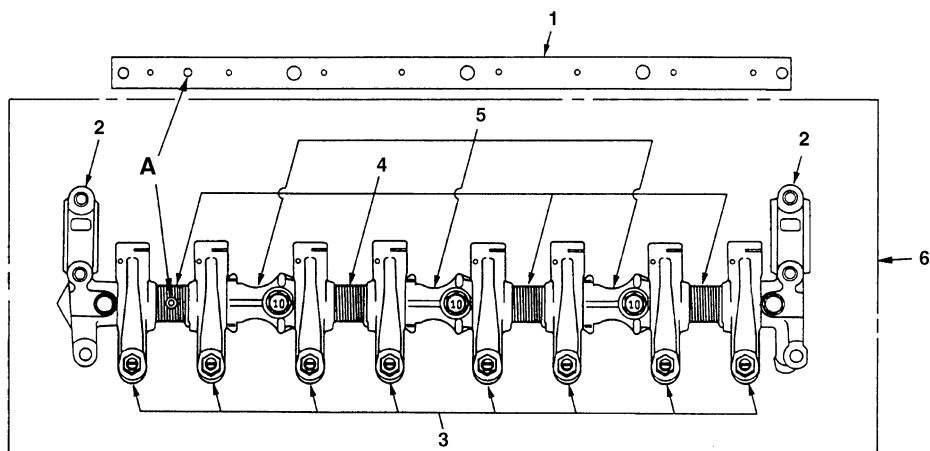
Rocker Arm Roller and Rocker Arm Pin

1. Pass a string through the rocker arm-roller clearance and measure the roller protrusion while pulling both ends of the string in the arrow-indicated directions to push out the roller.
2. Mark the measuring point and draw out the string. Measure the roller protrusion again while the roller is pushed in.
3. Note the difference in the above measurements is the standard roller-rocker arm pin clearance. Should the clearance exceed the limit, replace the rocker arm.

Rocker Arm Roller and Pin Clearance		mm (in)
Standard	Limit	
0.040 — 0.084 (0.0016 — 0.0033)	0.5 (0.02)	



Reassembly



N6A0158E

Legend

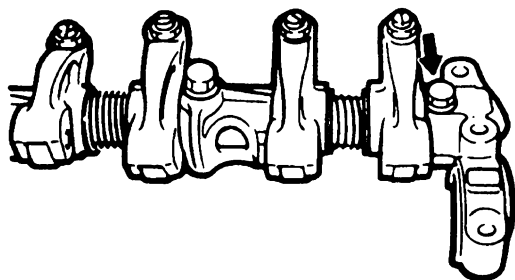
- | | |
|---------------------|-----------------------|
| A. Front mark | 4. Spring |
| 1. Rocker arm shaft | 5. Rocker arm bracket |
| 2. Camshaft bracket | 6. Valve cap |
| 3. Rocker arm | |

1. Rocker Arm Shaft

- 1) Use compressed air to thoroughly clean the rocker arm shaft oil holes.
- 2) Apply a coat of engine oil to the rocker arm shaft.
- 3) Install the rocker arm shaft with the "Front" mark facing up and toward the front of the engine.

2. Camshaft Bracket

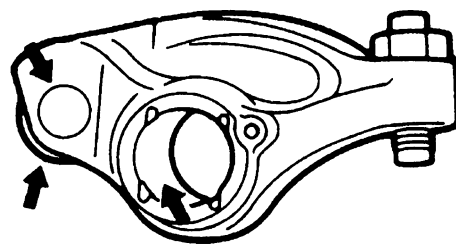
Install the camshaft bracket to the rocker arm shaft and temporarily tighten the camshaft bracket fixing bolt as shown in the illustration.



N6A0159E

3. Rocker Arm

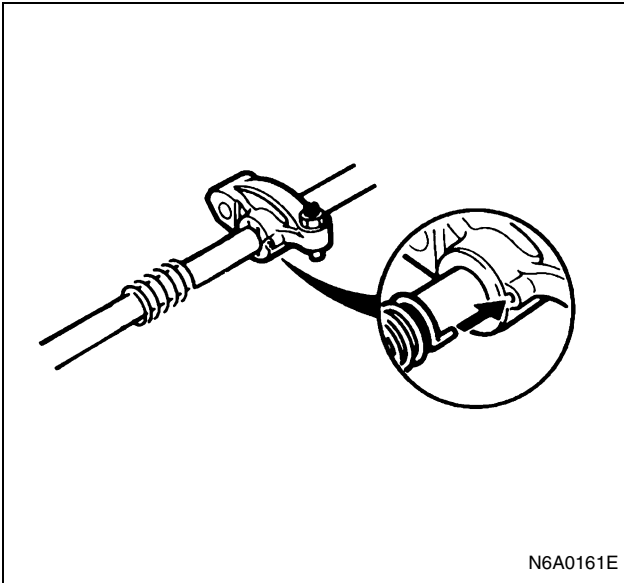
Apply engine oil to the rocker arm bushing and the roller pin and then install it to the rocker arm shaft.



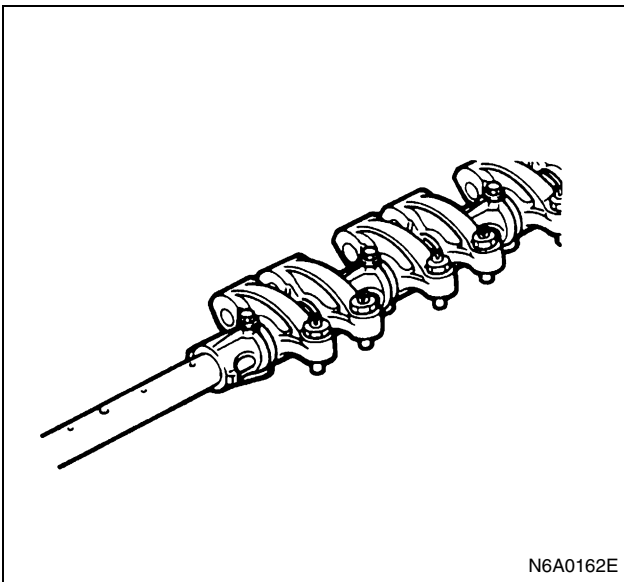
N6A0160E

4. Spring

Insert the spring end into the rocker arm.



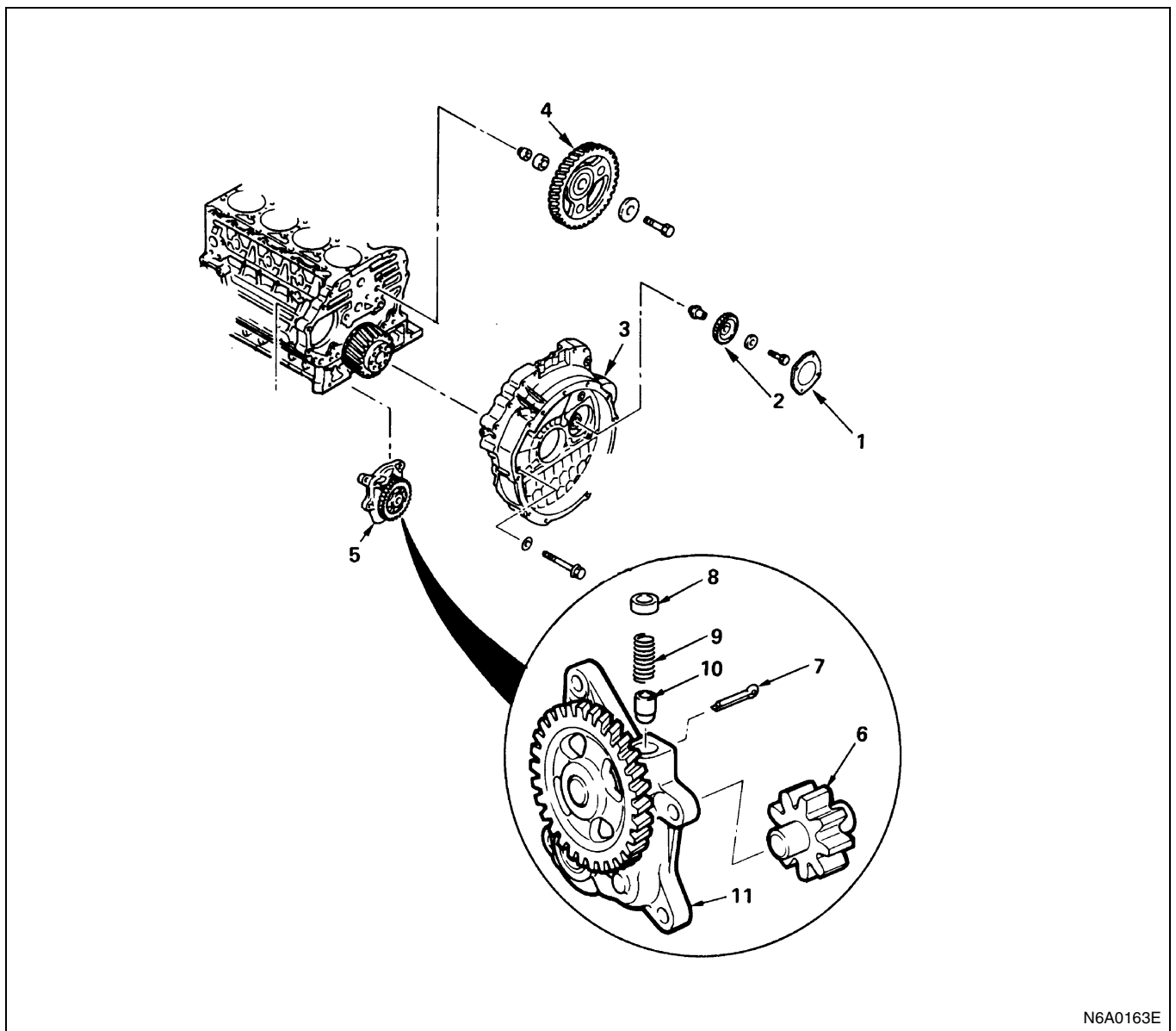
5. Rocker Arm Bracket



6. Camshaft Bracket
Temporarily tighten the camshaft bracket fixing bolt.
7. Valve Cap
8. Rocker Arm Shaft Assembly
Above works refer to "CYLINDER HEAD" section in this manual.

OIL PUMP

Component



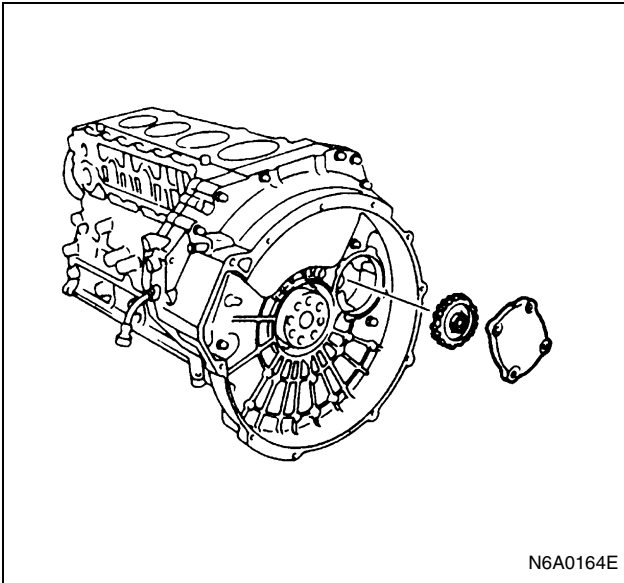
N6A0163E

Legend

- | | |
|--|----------------------------|
| 1. Power steering pump idle gear cover | 7. Cotter pin |
| 2. Power steering pump idle gear | 8. Spring seat |
| 3. Flywheel housing | 9. Oil relief valve spring |
| 4. Idle gear A | 10. Oil relief valve |
| 5. Oil pump assembly | 11. Pump cover |
| 6. Driven gear and shaft | |

Disassembly

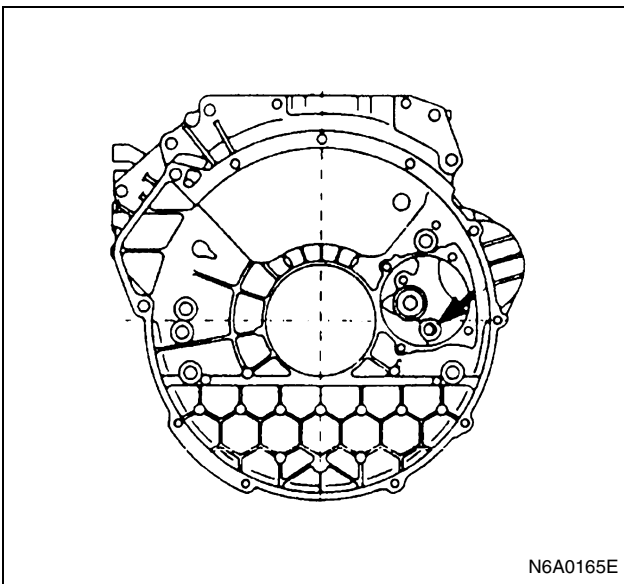
1. Power Steering Pump Idle Gear Cover
2. Power Steering Pump Idle Gear



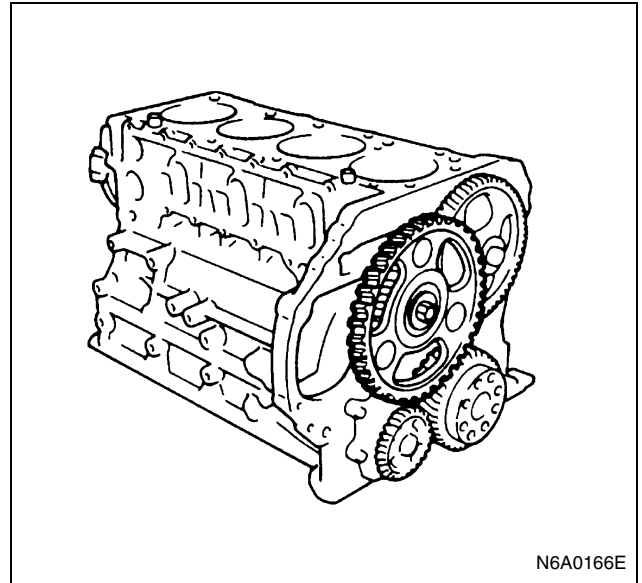
3. Flywheel Housing

Notice:

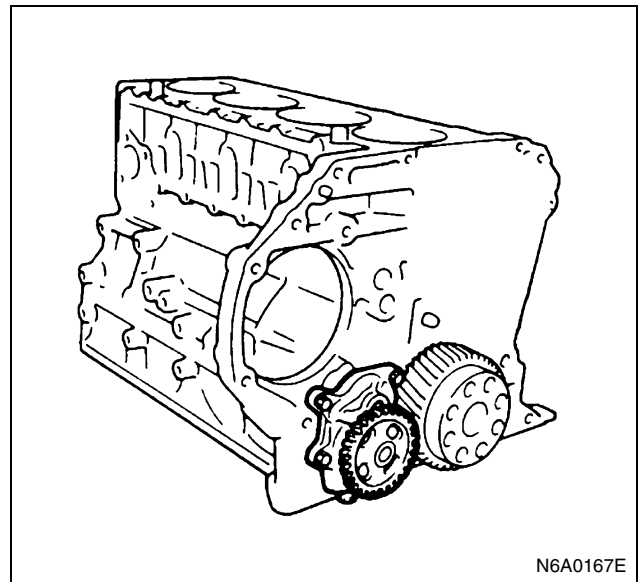
Be careful not to fail to remove the bolts shown in the illustration.



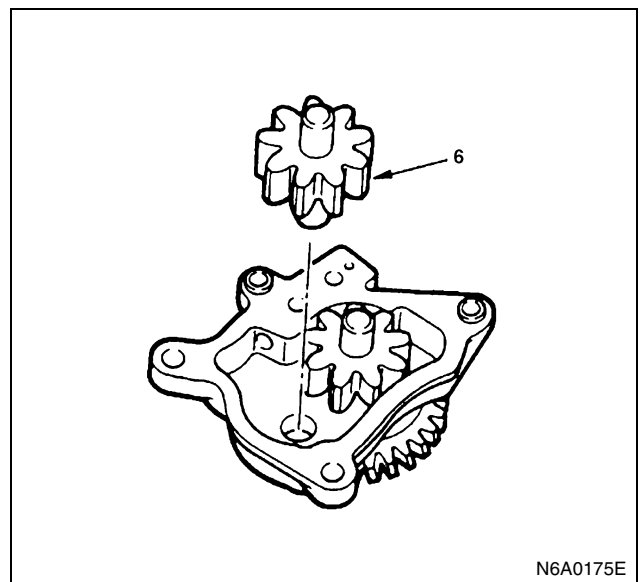
4. Idle Gear A



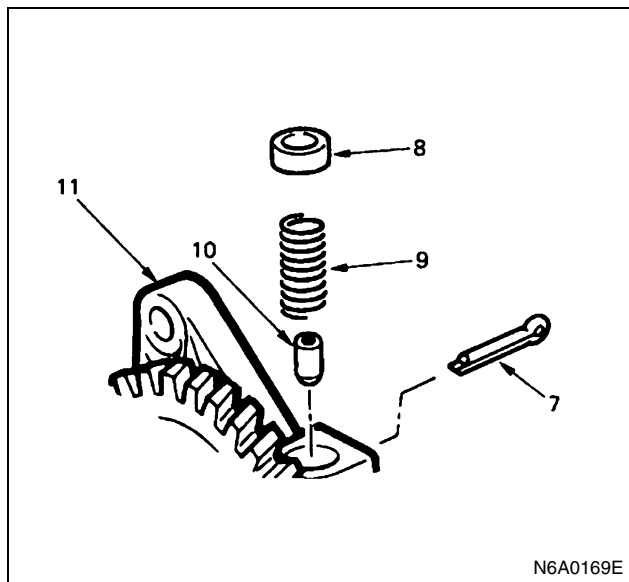
5. Oil Pump Assembly



6. Driven Gear and Shaft



7. Cotter Pin
8. Spring Seat
9. Oil Relief Valve Spring
10. Oil Relief Valve
11. Pump Cover



Inspection and Repair

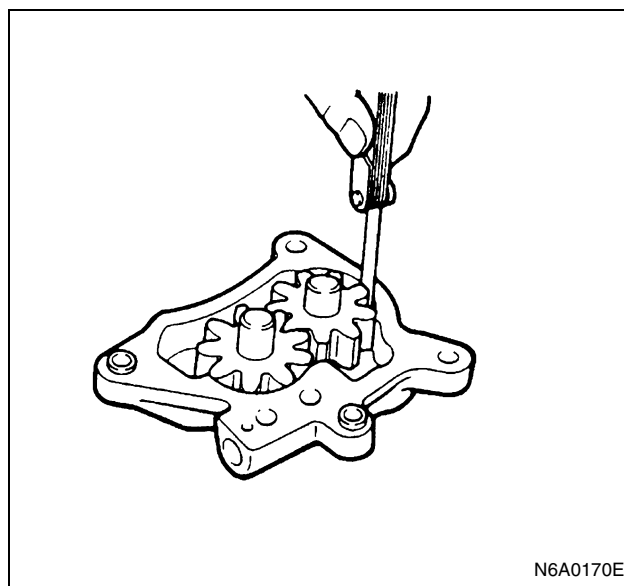
Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

Gear Teeth and Cover Inner Wall Clearance

Use a feeler gauge to measure the clearance between the gear teeth and the cover inner wall.

If the clearance between the gear teeth and the cover inner wall exceeds the specified limit, the oil pump assembly must be replaced.

Gear Teeth and Cover Inner Wall Clearance		mm (in)
Standard	Limit	
0.125 — 0.220 (0.0049 — 0.0087)	0.3 (0.012)	

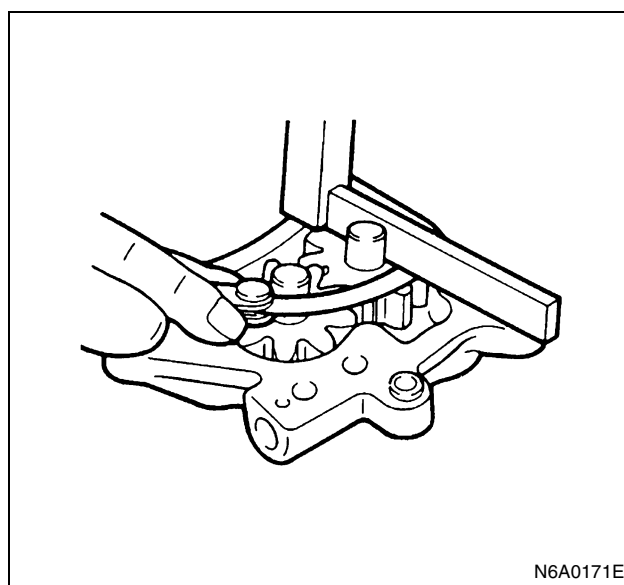


Gear and Cover Clearance

Use a feeler gauge to measure the clearance between the cover and the gear.

If the clearance between the gear and the cover exceeds the specified limit, the oil pump assembly must be replaced.

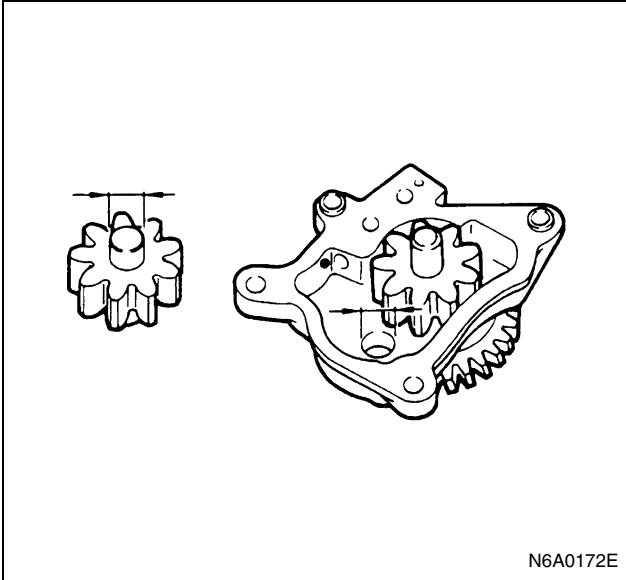
Gear and Cover Clearance		mm (in)
Standard	Limit	
0.064 — 0.109 (0.0025 — 0.0043)	0.2 (0.008)	



Driven Gear Shaft and Bushing Clearance

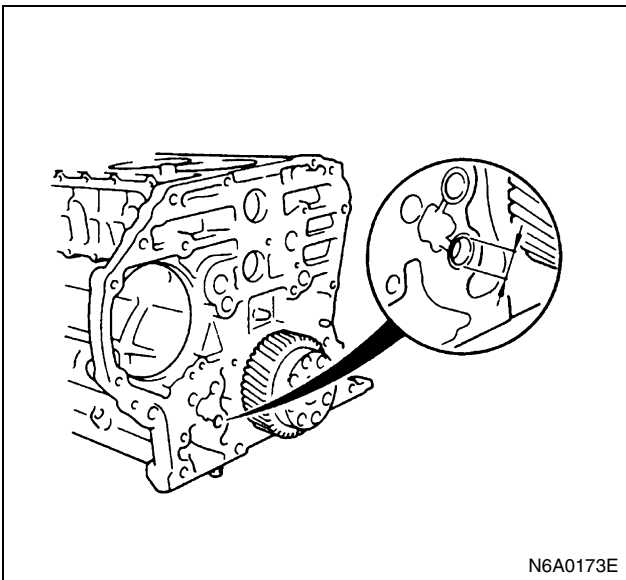
1. Use a micrometer to measure the gear shafts outside diameter.

Gear Shaft Outside Diameter		mm (in)
Standard	Limit	
15.989 — 16.000 (0.6295 — 0.6299)	15.9 (0.626)	



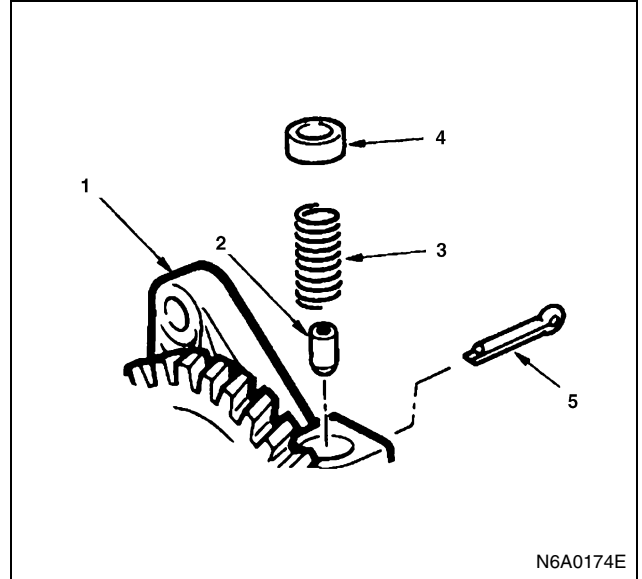
2. Use an inside dial indicator or inside micrometer to measure the pump cover bushing inside diameter and the cylinder body inside diameter. If clearance between the gear shaft and the bushing exceeds the specified limit, the oil pump assembly must be replaced.

Gear Shaft and Bushing Clearance		mm (in)
Standard	Limit	
0.04 — 0.07 (0.0016 — 0.0028)	0.2 (0.012)	

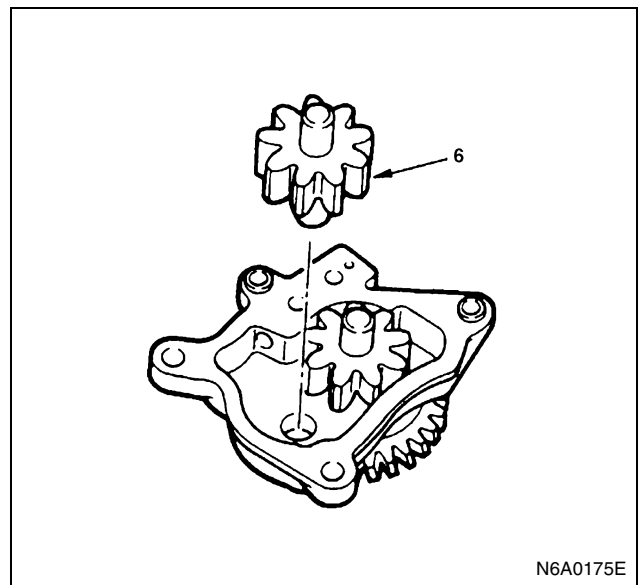


Reassembly

1. Pump Cover
2. Oil Relief Valve
3. Oil Relief Valve Spring
4. Sprig Seat
5. Cotter Pin



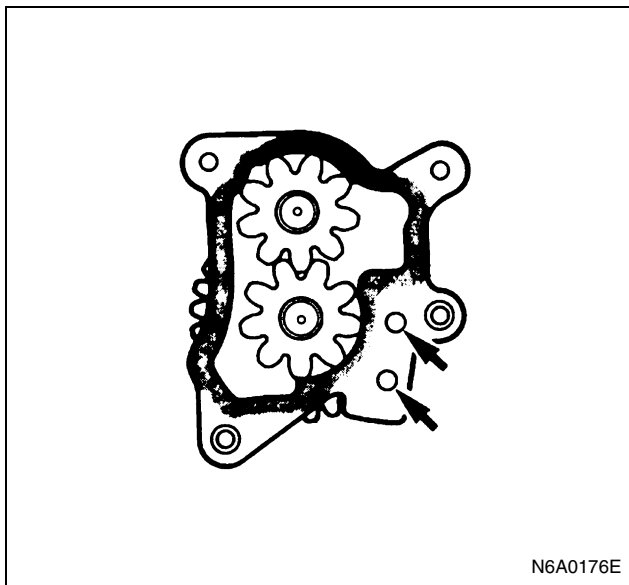
6. Driven Gear and Shaft
Apply the engine oil to the driven gear shaft.



7. Oil Pump Assembly
- 1) Carefully wipe any foreign material from cylinder body rear surface.
 - 2) Apply the recommended liquid gasket (Three Bond 1141E) or its equivalent to the shaded areas shown in the illustration.

Caution:

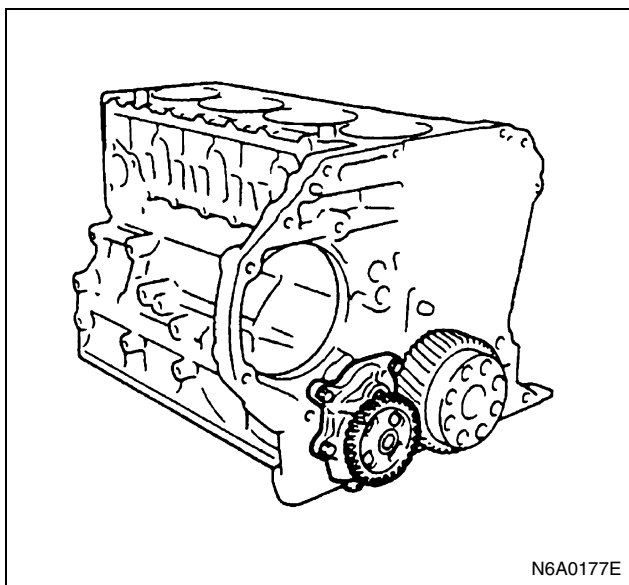
Be careful that no liquid gasket gets into the holes in the arrow-marked portion in the illustration and the inside of the oil pump cover.



- 3) Install the oil pump to the cylinder body.
- 4) Tighten the oil pump to the specified torque.

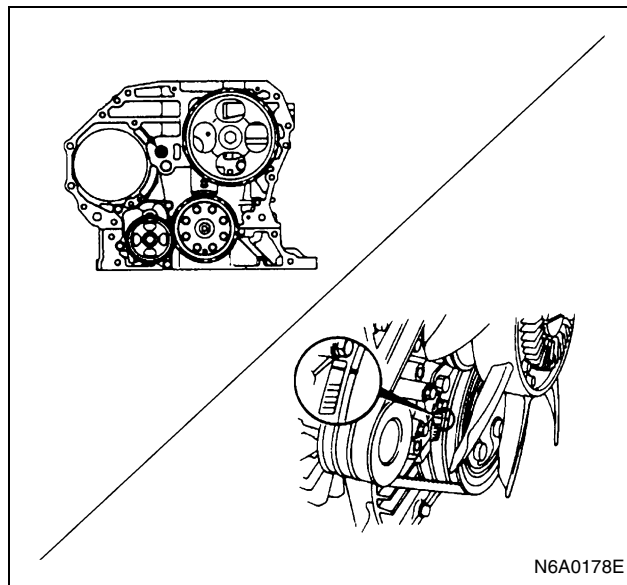
Tighten:

Oil pump bolt to 31 N·m (3.2 kg·m / 23 lb·ft)



8. Idle Gear A

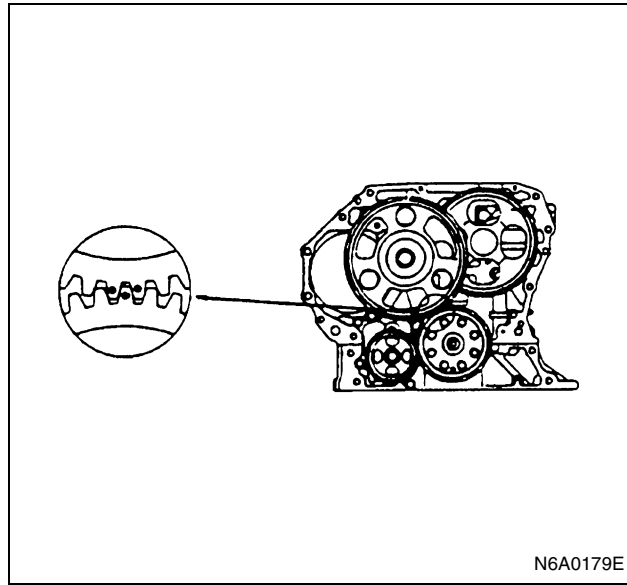
- 1) Turn the crankshaft clockwise so that the engagement mark of the crankshaft gear faces to the shaft center of the idle gear A and the No.1 cylinder piston comes to the top dead center.



- 2) Align the crankshaft gear with the engagement mark of the idle gear and install the idle gear A.

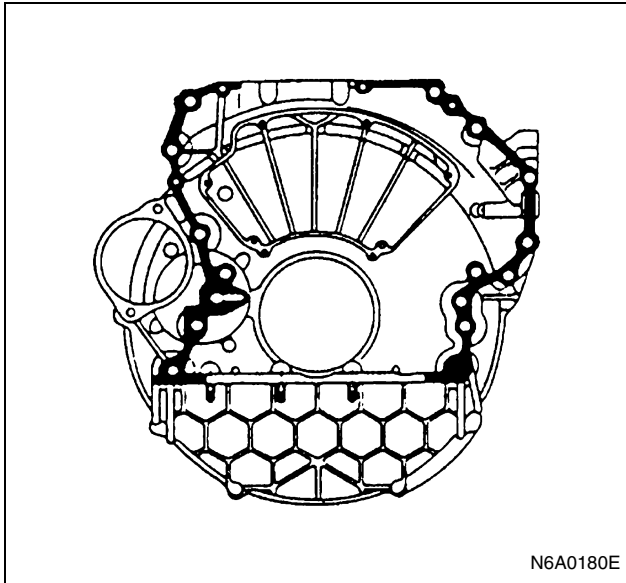
Tighten:

Idle gear A bolt to 133 N·m (13.6 kg·m / 98 lb·ft)



9. Flywheel Housing

- 1) Carefully wipe any foreign material from the cylinder body rear face.
- 2) Apply the recommended liquid gasket (Three Bond 1207C) or its equivalent to the shaded areas shown in the illustration.

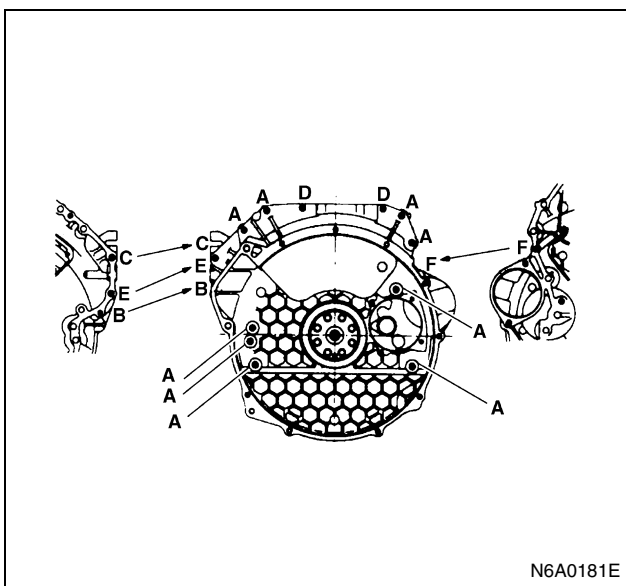


- 3) Align the cylinder body knock pins with the flywheel housing knock pin holes.
- 4) Tighten the flywheel housing bolts to the specified torque shown in the illustration.

Tighten:

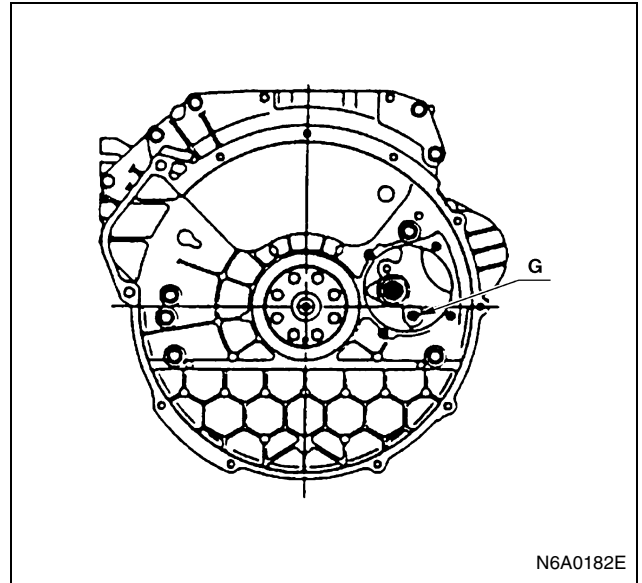
Flywheel housing bolt to

- A: 96 N·m (9.8 kg·m / 71 lb·ft)
- B: 48 N·m (4.9 kg·m / 35 lb·ft)
- C: 94 N·m (9.6 kg·m / 69 lb·ft)
- D: 25 N·m (2.6 kg·m / 19 lb·ft)
- E: 76 N·m (7.7 kg·m / 56 lb·ft)
- F: 38 N·m (3.9 kg·m / 28 lb·ft)
- Tighten the bolts marked with "E" or "B" from the injection pump side, and those with "F" from the cylinder body side.



Tighten:

Flywheel housing bolt (G) to 96 N·m (9.8 kg·m / 71 lb·ft)

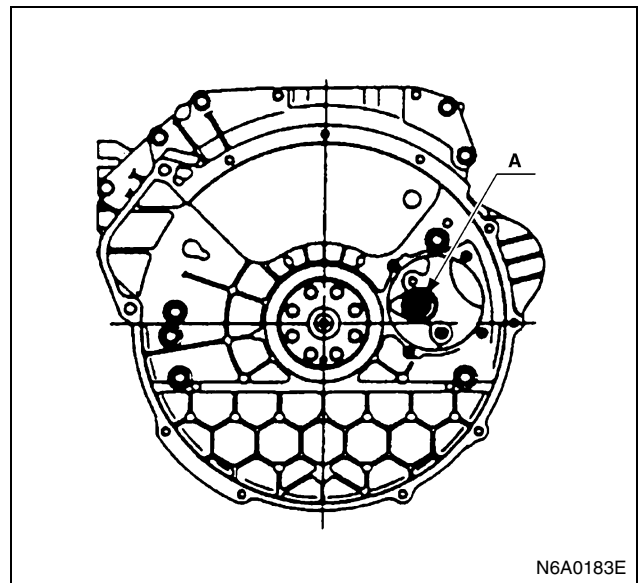


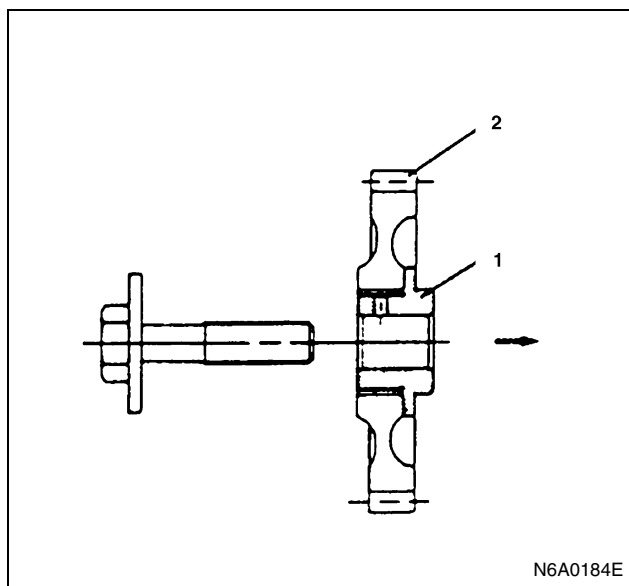
10. Power Steering Pump Idle Gear

- 1) Apply the engine oil to the idle gear shaft.
- 2) Install the idle gear shaft (1) with the idle gear (2) to the cylinder body "A" portion as shown in the illustration.

Tighten:

Idle gear shaft bolt to 133 N·m (13.6 kg·m / 98 lb·ft)

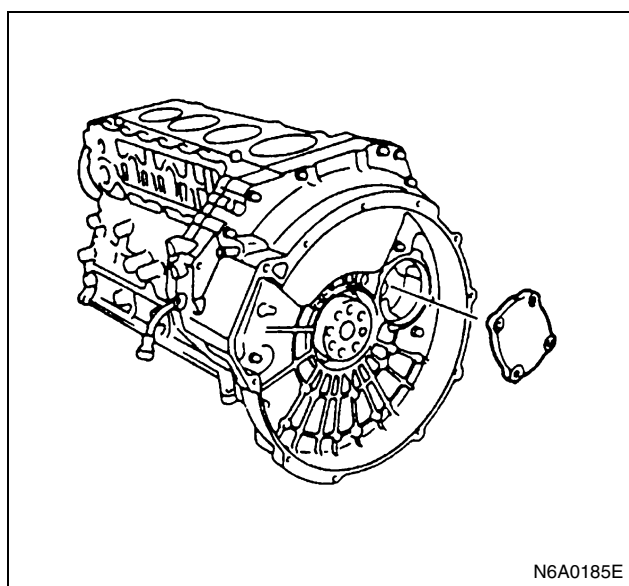




11. Power Steering Pump Idle Gear Cover
Install the gear cover with the O-ring.

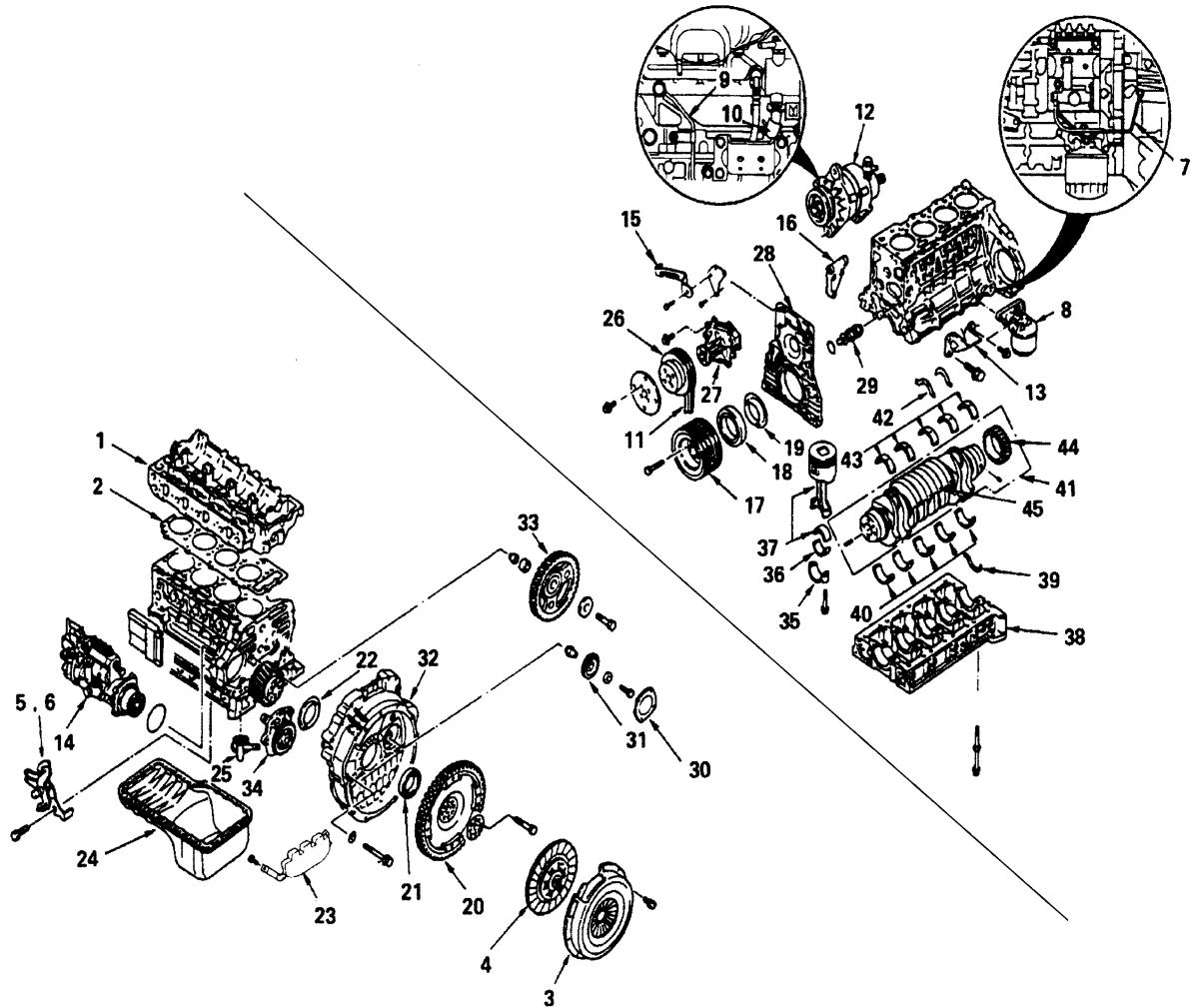
Tighten:

Gear cover bolt to 19 N·m (1.9 kg·m / 14 lb·ft)



CRANKSHAFT

Component



N6A1621E

Legend

- | | |
|-----------------------------------|---|
| 1. Cylinder head assembly | 24. Oil pan |
| 2. Cylinder head gasket | 25. Oil pump strainer |
| 3. Clutch pressure plate assembly | 26. Water pump pulley |
| 4. Driven plate | 27. Water pump |
| 5. Engine control wire | 28. Front retainer |
| 6. Engine control lever assembly | 29. Oil thermo valve |
| 7. Oil pipe | 30. Power steering pump idle gear cover |
| 8. Oil filter assembly | 31. Power steering pump idle gear |
| 9. Vacuum pump oil pipe | 32. Flywheel housing |
| 10. Vacuum pump rubber hose | 33. Idle gear A |
| 11. Fan belt | 34. Oil pump assembly |
| 12. Generator | 35. Connecting rod cap assembly |
| 13. Engine foot | 36. Connecting rod lower bearing |
| 14. Injection pump assembly | 37. Piston and connecting rod assembly |
| 15. Fan belt adjust plate | 38. Crankcase |
| 16. Generator bracket | 39. Thrust bearing lower |
| 17. Crankshaft damper pulley | 40. Crankshaft bearing lower |
| 18. Crankshaft front oil seal | 41. Crankshaft assembly |
| 19. Crankshaft front slinger | 42. Thrust bearing upper |
| 20. Flywheel | 43. Crankshaft bearing upper |
| 21. Crankshaft rear oil seal | 44. Crankshaft gear |
| 22. Crankshaft rear slinger | 45. Crankshaft |
| 23. Spacer rubber | |
-

Disassembly

1. Cylinder Head Assembly
Above works refer to "CYLINDER HEAD" section in this manual.
2. Cylinder Head Gasket

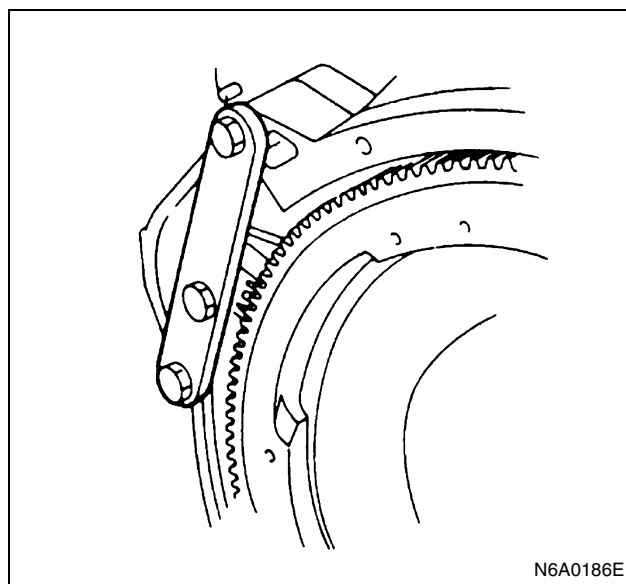
Caution:

Do not reuse the cylinder head gasket.

3. Clutch Pressure Plate Assembly
4. Driven Plate
5. Engine Control Wire
6. Engine Control Lever Assembly
7. Oil Pipe
8. Oil Filter Assembly
9. Vacuum Pump Oil Pipe
10. Vacuum Pump Rubber Hose
11. Fan Belt
12. Generator
13. Engine Foot
14. Injection Pump Assembly
15. Fan Belt Adjust Plate
16. Generator Bracket
Above works refer to "CYLINDER BLOCK" section in this manual.
17. Crankshaft Damper Pulley

- 1) Use the crankshaft stopper to prevent the crankshaft from turning.
Crankshaft Stopper: 5-8840-2230-0

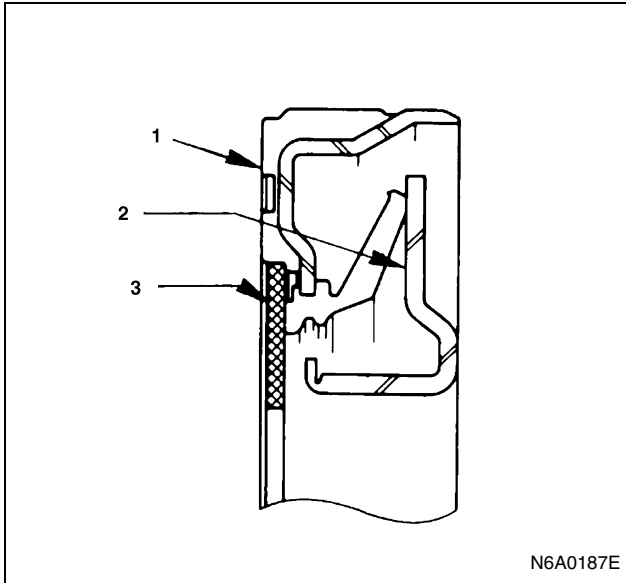
- 2) Loosen the damper pulley bolts and remove the damper pulley.



18. Crankshaft Front Oil Seal

Caution:

Be careful not to damage the crankshaft oil seal contact surface during the removal procedure.

**Legend**

- 1. Oil seal
- 2. Slinger
- 3. Felt

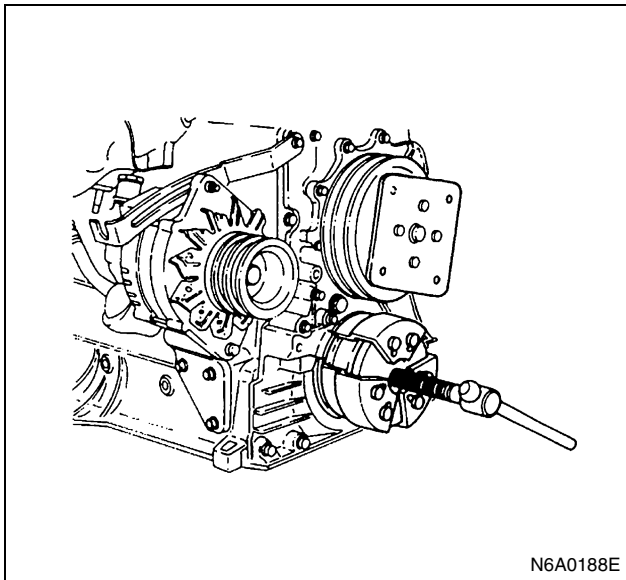
19. Crankshaft Front Slinger

Use the slinger puller to pull out the slinger.

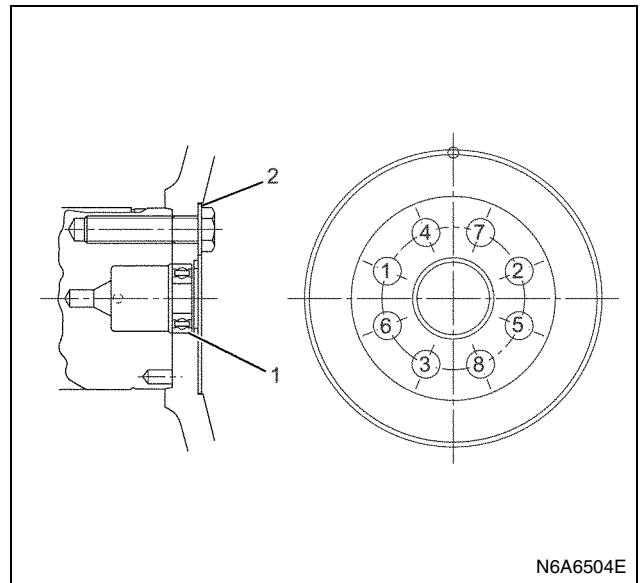
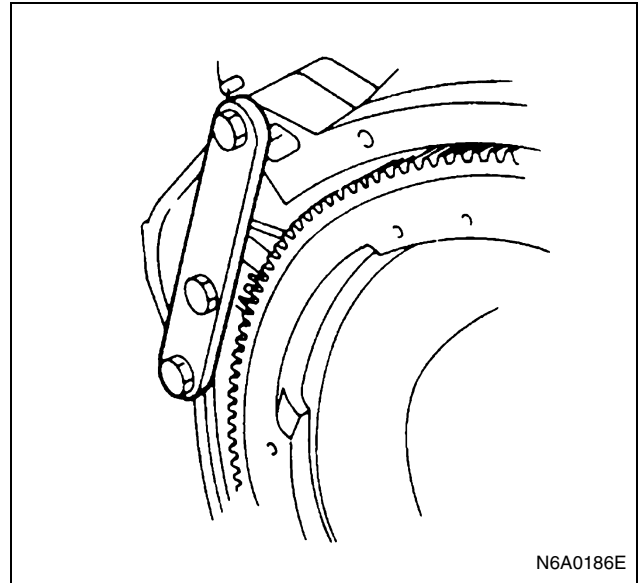
Slinger Puller: 5-8840-2360-0

Notice:

If the oil seal has been removed, both the oil seal and slinger must be replaced as a set.

**20. Flywheel Assembly**

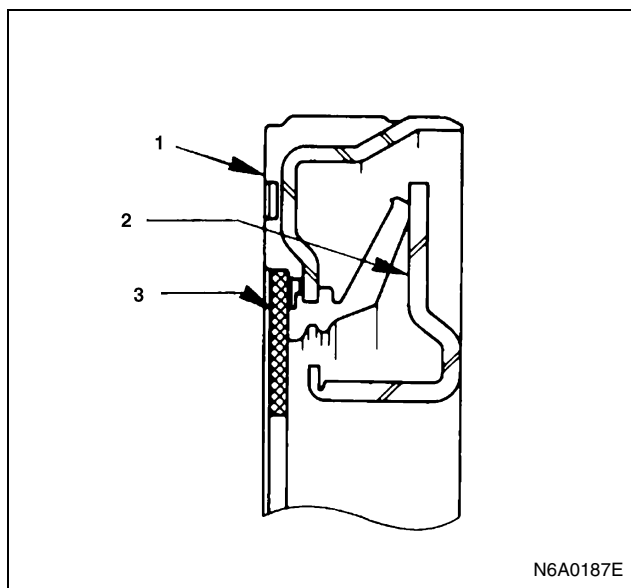
- 1) Use the crankshaft stopper to prevent the crankshaft from turning
Crankshaft Stopper: 5-8840-2230-0
- 2) Loosen the flywheel bolts in numerical order a little at a time as shown in the illustration.
- 3) Remove the flywheel stopper and the flywheel assembly.

**Legend**

- 1. Washer
- 2. Pilot bearing

21. Crankshaft Rear Oil Seal**Caution:**

Be careful not to damage the crankshaft oil seal contact surface during the removal procedure.



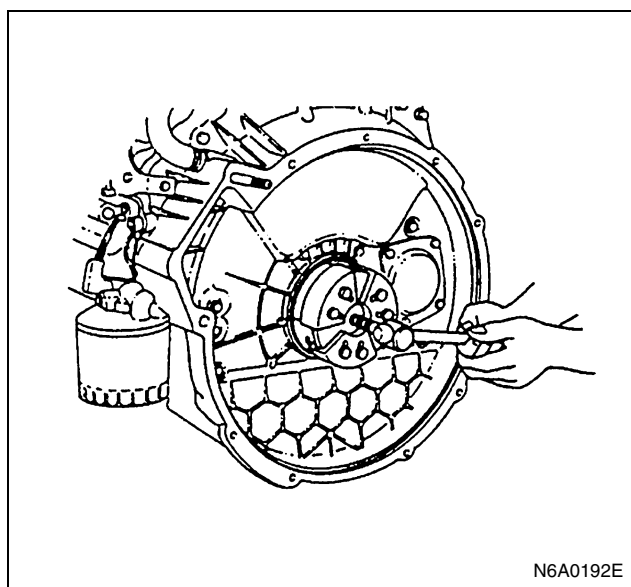
N6A0187E

Legend

1. Oil seal
2. Slinger
3. Felt

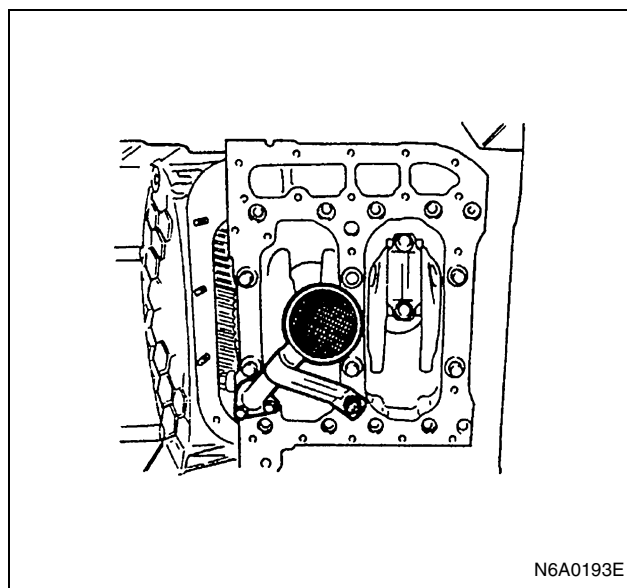
22. Crankshaft Rear Slinger

Use the slinger puller to pull out the slinger.
Slinger Puller: 5-8840-2360-0



N6A0192E

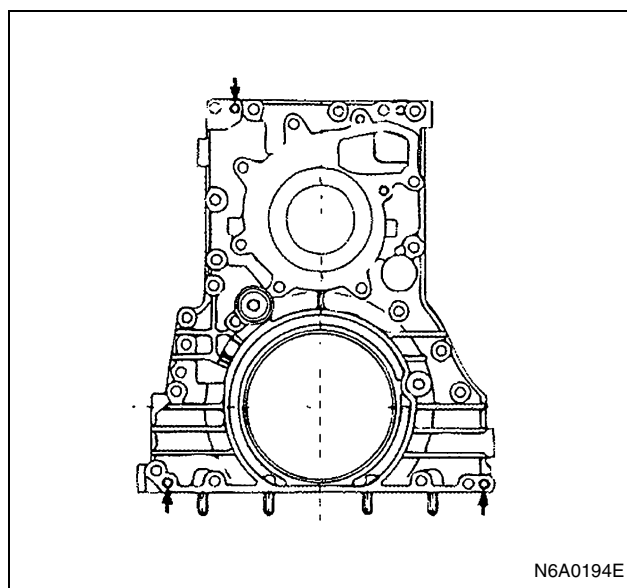
23. Spacer Rubber
24. Oil Pan
25. Oil Pump Strainer
26. Water Pump Pulley
27. Water Pump



N6A0193E

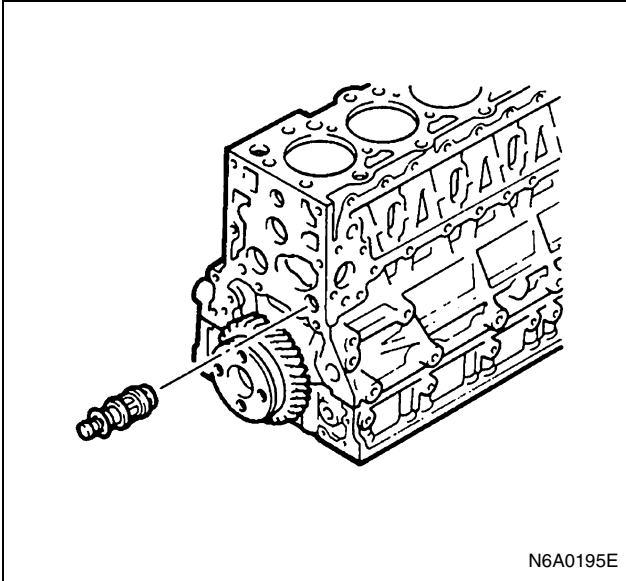
28. Front Retainer

Install the three front retainer fixing bolts to the front retainer replacer holes as shown in the illustration, and tighten the bolts alternately a little at a time.

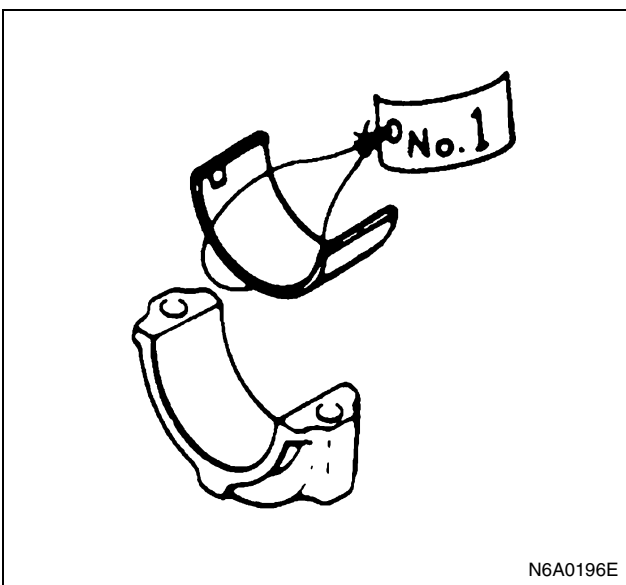


N6A0194E

29. Oil Thermo Valve (4HF1, 4HF1-2, 4HG1, 4HG1-T)
Pull out the thermo valve from the cylinder body.

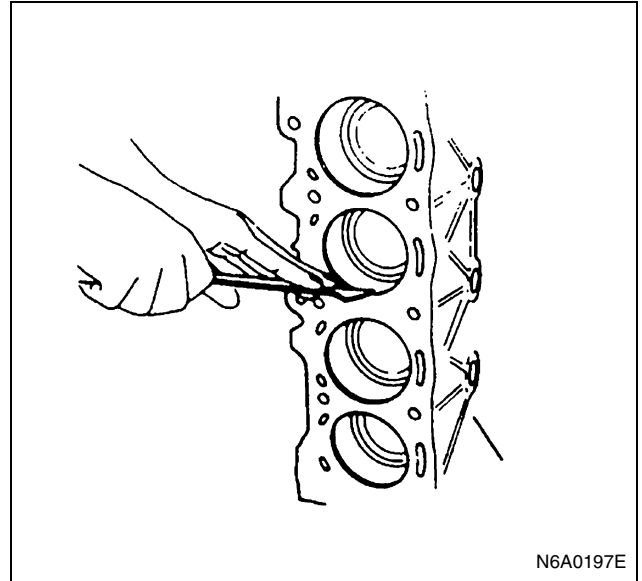


30. Bypass Valve (4HE1-TC)
Pull out the bypass valve from the cylinder body.
31. Power Steering Pump Idle Gear Cover
32. Power Steering Pump Idle Gear
33. Flywheel Housing
34. Idle Gear A
35. Oil Pump Assembly
Above works refer to "OIL PUMP" section in this manual.
36. Connecting Rod Cap Assembly
37. Connecting Rod Lower Bearing
 - 1) Take out the connecting rod bearing cap bolts and remove the bearing cap with the lower bearing.
 - 2) If the connecting rod lower bearings are to be reinstalled, mark their fitting positions by tagging each bearing with the cylinder number from which it was removed.



38. Piston and Connecting Rod Assembly

- 1) To facilitate smooth removal of piston, remove carbon from the upper part of the cylinder wall using a scraper or equivalent.



- 2) Remove the piston and connecting rod assembly upward by pushing on the edge of the connecting rod with a hammer handle or equivalent.
- 3) If the connecting rod bearing are to be reinstalled, mark their fitting positions by tagging each bearing with the cylinder number from which it was removed.

Caution:

Do not bend or damage the oiling jet.

Notice:

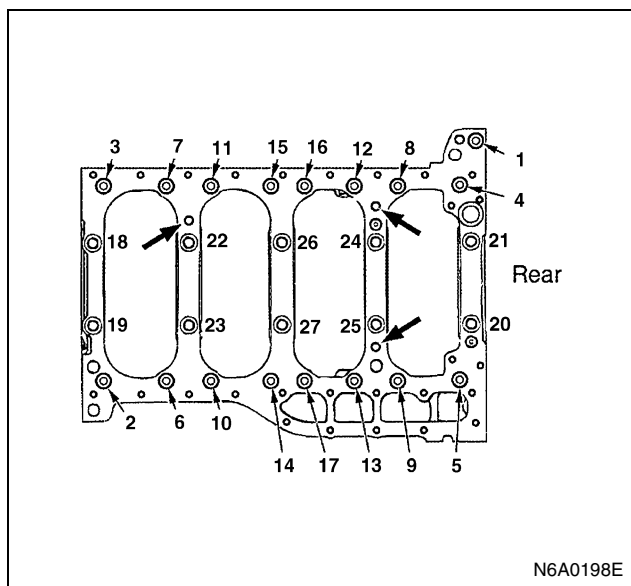
When removing the piston and connecting rod assembly, pull the connecting rod in parallel with the cylinder bore.

39. Crankcase

- 1) Loosen the crankcase bolts in numerical order a little at a time.
- 2) Install the three crankcase fixing bolts (See left arrow marks) to the crankcase replacer holes as shown in the illustration, and tighten the bolts alternate a little at a time.

Notice:

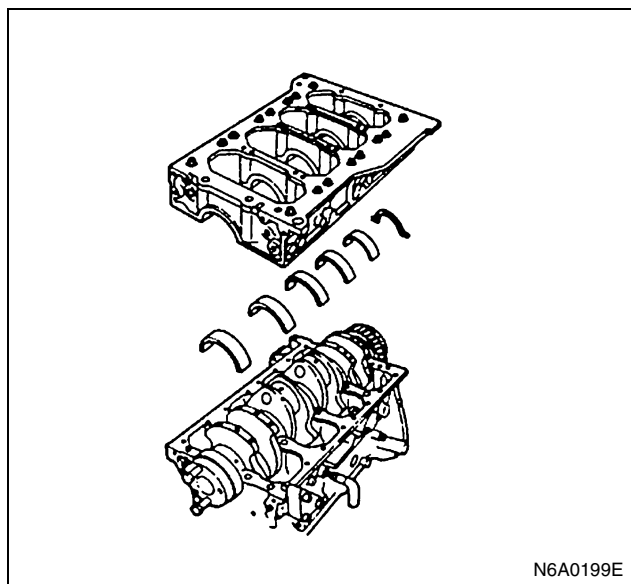
When removing the crankcase, be sure to remove the oil pump and the generator bracket before that.



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40. Thrust Bearing Lower

41. Crankshaft Bearing Lower

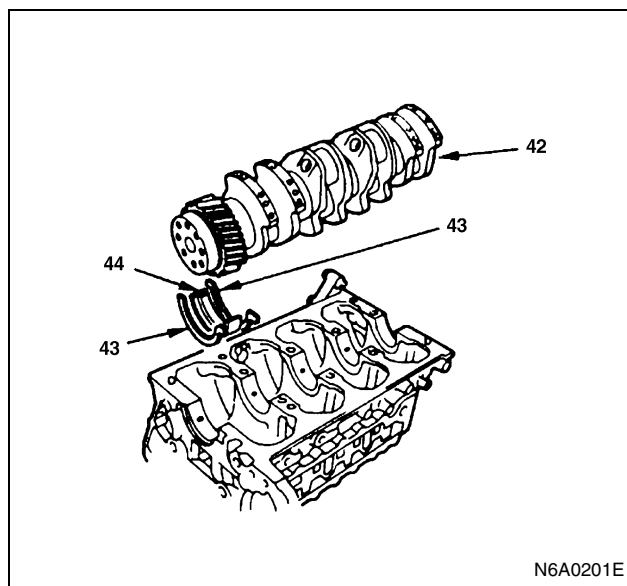


N6A0199E

42. Crankshaft Assembly

43. Thrust Bearing Upper

44. Crankshaft Bearing Upper



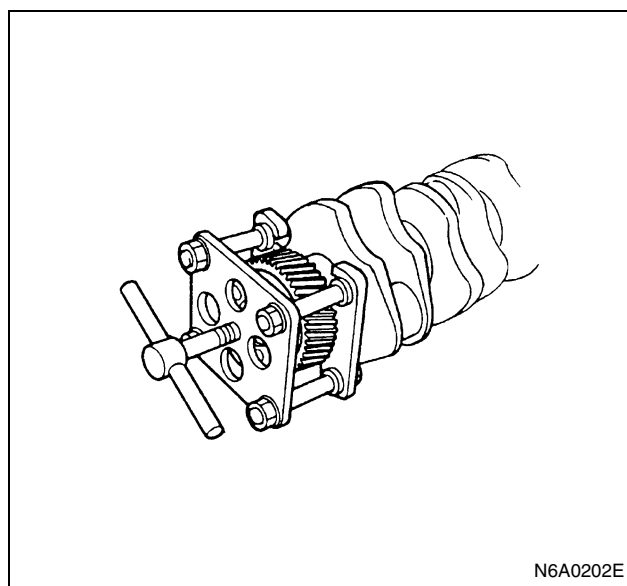
N6A0201E

45. Crankshaft Gear

1) Use the crankshaft gear remover to remove the crankshaft gear.

Crankshaft Gear Remover: 8-9439-6818-0

2) Remove the crankshaft feather key.



N6A0202E

46. Crankshaft

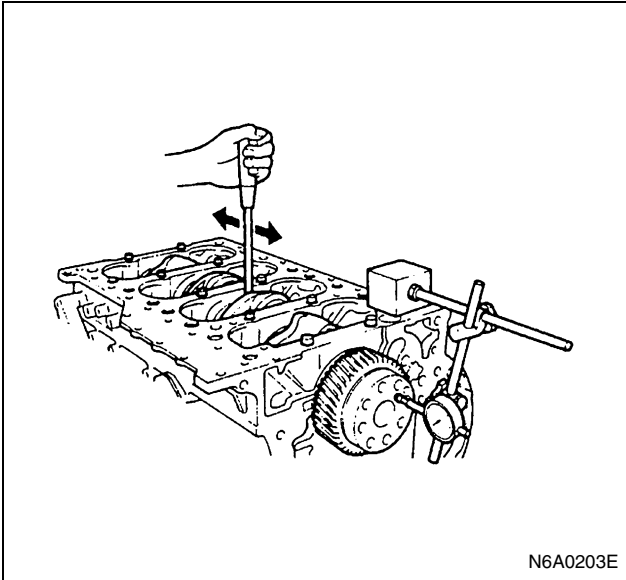
Inspection and Repair

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

Crankshaft End Play

1. Set the dial indicator to the crankshaft end and measure the end play.
2. If the measured value exceeds the specified limit, the thrust bearings must be replaced.

Crankshaft End Play		mm (in)
Standard	Limit	
0.104 — 0.205 (0.0041 — 0.0081)	0.35 (0.014)	



Crankshaft and Bearing

Inspect the surface of the crankshaft journals and crankpins for excessive wear and damage.

Inspect the oil seal fitting surfaces for excessive wear and damage.

Inspect the oil ports for obstructions.

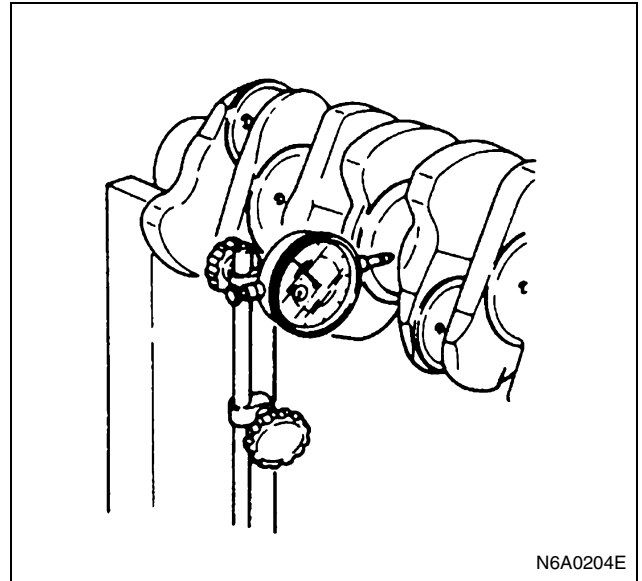
Crankshaft Run-Out

1. Set a dial indicator to the center of the crankshaft journal.
2. Gently turn the crankshaft in the normal direction of rotation.

Read the dial indicator as you turn the crankshaft.

If the measured value exceeds the specified limit, the crankshaft must be replaced.

Crankshaft Run-Out		mm (in)
Standard	Limit	
0.05 (0.002) or less	0.30 (0.012)	

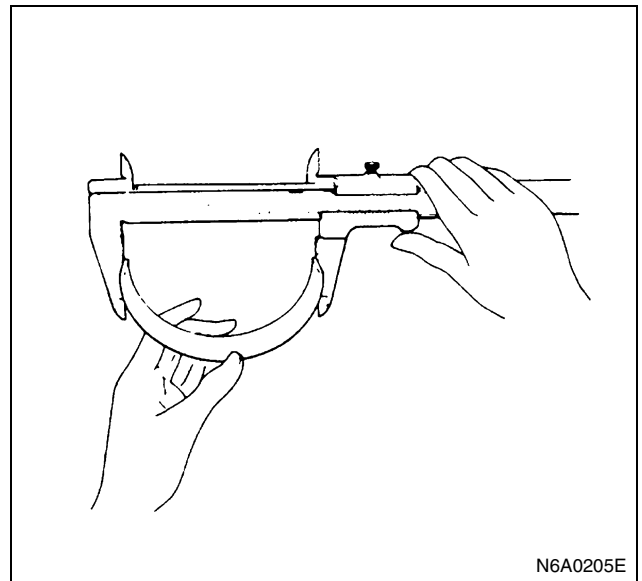


Bearing Spread

Use a vernier caliper to measure the bearing spread.

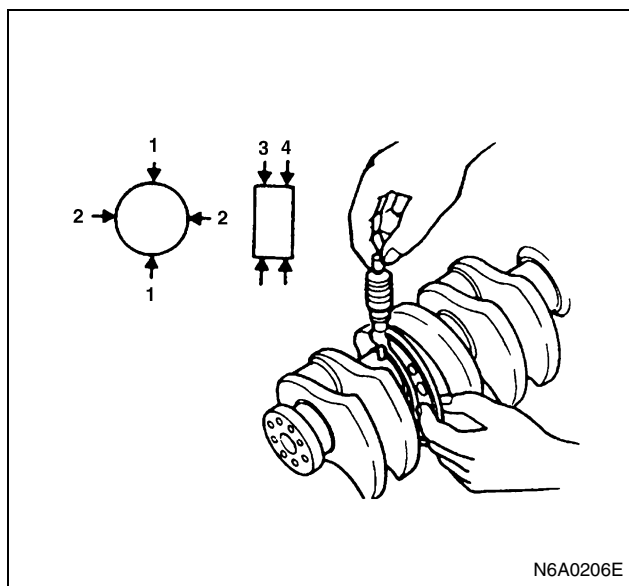
If the measured value is less than the specified limit, the bearing must be replaced.

Bearing Spread		mm (in)
Limit		87 (3.43)



Crankshaft Journal and Crankpin Diameter

1. Use a micrometer to measure the crankshaft journal diameter across points (1) — (1) and (2) — (2).
2. Use the micrometer to measure the crankshaft journal diameter at the two points (3) and (4).



3. Repeat Steps 1 and 2 to measure the crankpin diameter.

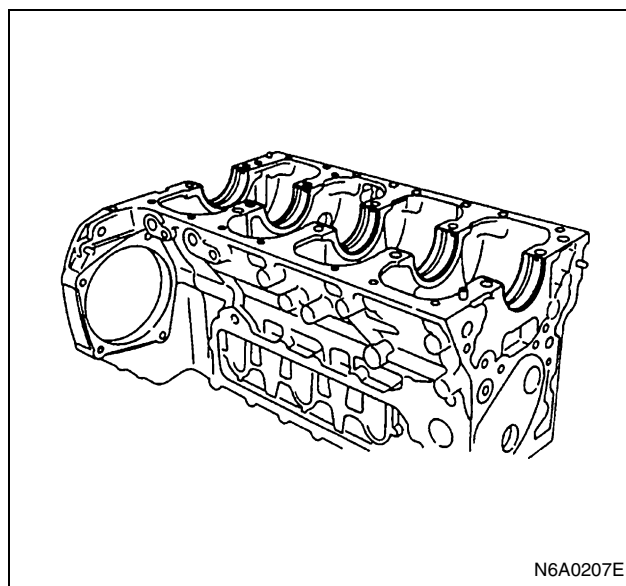
If the measured values are less than the limit, the crankshaft must be reground or replaced.

Crankshaft Journal and Crankpin Diameter		mm (in)	
Engine model		Standard	Limit
ALL	No.1,2,4 and 5 Journal	81.905 — 81.925 (3.2246 — 3.2254)	81.85 (3.2224)
ALL	No.3 Journal	81.891 — 81.911 (3.2240 — 3.2248)	81.85 (3.2224)
Except 4HE1-TC	Crankpin	65.902 — 65.922 (2.5946 — 2.5954)	65.85 (2.5925)
4HE1-TC	Crankpin	72.902 — 72.922 (2.8702 — 2.8433)	72.85 (2.8681)

Crankshaft Journal and Crankpin Diameter Uneven Wear		mm (in)
Except 4HE1-TC	Limit	0.050 (0.002)
4HE1-TC		0.0050 (0.0002)

Crankshaft Journal and Bearing Clearance

1. Clean the cylinder body and crankcase, the journal bearing fitting surface, and the journal bearings.
2. Install the bearings to the cylinder body and crankcase.
3. Install the crankcase to the cylinder body.

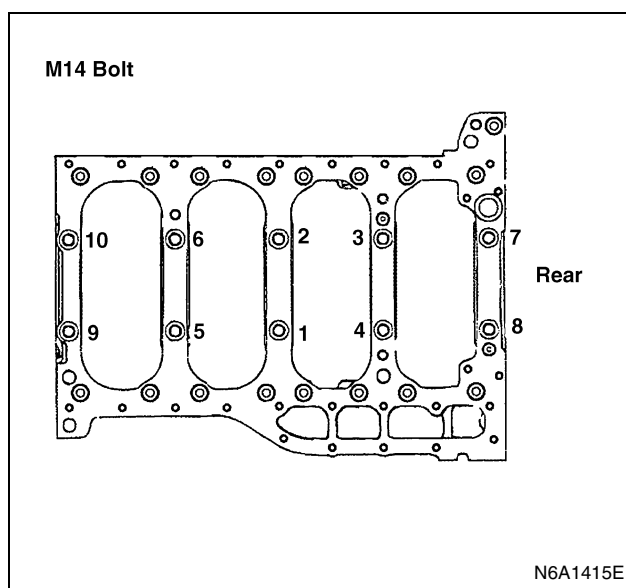


4. Tighten the crankcase to the specified torque in the numerical order shown in the illustration.

Tighten:

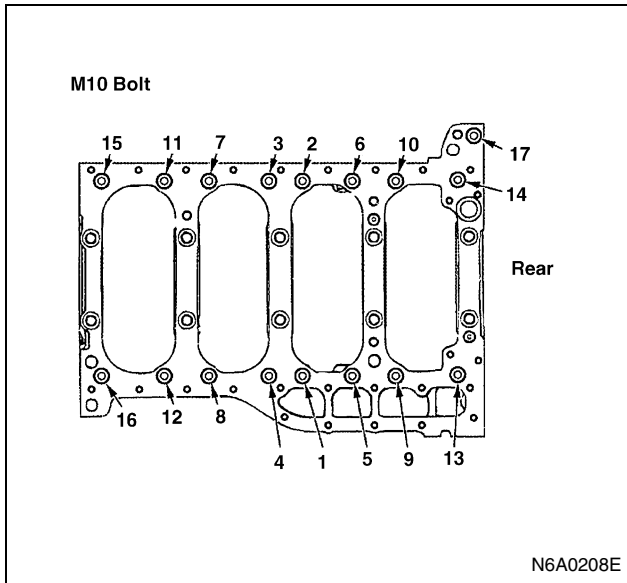
Crankcase bolt (M14: (1) — (10)) to

- 1st step: 98 N·m (10 kg·m / 72 lb·ft)
- 2nd step: 132 N·m (13.5 kg·m / 98 lb·ft)
- 3rd step: 30 — 60°



Tighten:

Crankcase bolt (M10: (1) — (17)) to 37 N·m (3.8 kg·m / 27 lb·ft)



5. Use a dial indicator to measure the crankshaft journal inside diameter.
6. If the clearance between the crankshaft journal and the bearing exceeds the specified limit, the crankshaft must be either reground or replaced.

Crankshaft Journal and Bearing Clearance		mm (in)
	Standard	Limit
No.1, 2, 4 and 5 Journal	0.037 — 0.072 (0.0015 — 0.0028)	0.11 (0.0043)
No.3 Journal	0.051 — 0.086 (0.0020 — 0.0034)	0.11 (0.0043)

7. Remove the crankcase and the bearings.

Undersized Crankshaft Journal Bearing Availability (Except 4HE1-TC)		mm (in)
0.25 (0.01)	0.50 (0.02)	

Crankshaft Bearing Selection

Refer to the following table when replacing the crankshaft and/or the crankshaft bearings.

Crankshaft bearing selection is based on the measured diameters of the crankshaft journals and the bearing housing.

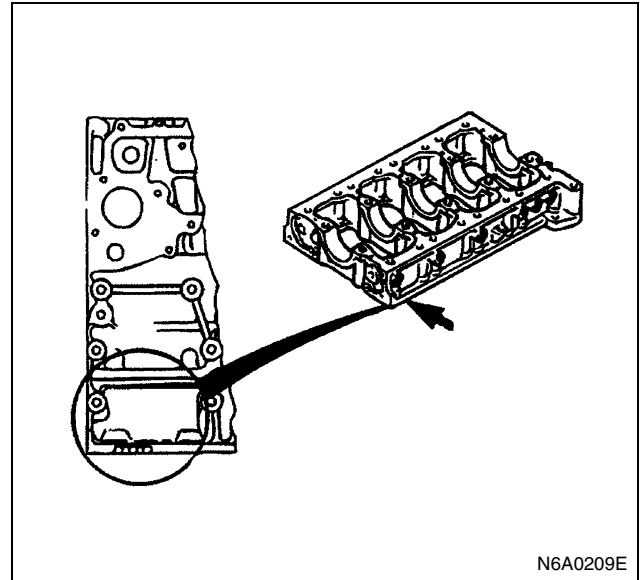
Match the crankshaft bearing housing grade marks and the crankshaft journal grade marks in the table below to determine the correct crankshaft bearing size.

Crankshaft Bearing Insert Grade Mark Position

The crankshaft bearing housing grade marks (1 or 2) are stamped collectively for all cylinders on the underside of the left front portion of the crankcase.

Example:

1	2	1	1	2
↑	↑	↑	↑	↑
No.1 Bearing Housing	No. 2 Bearing Housing	No. 3 Bearing Housing	No. 4 Bearing Housing	No. 5 Bearing Housing



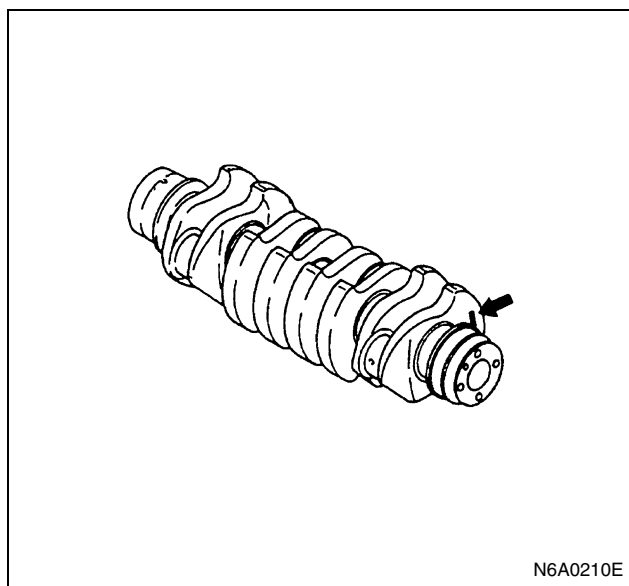
Crankshaft Journal Grade Mark Position

The crankshaft journal grade marks (1 or 2) are stamped collectively for all cylinders on the front side of the crankshaft No.1 balancer.

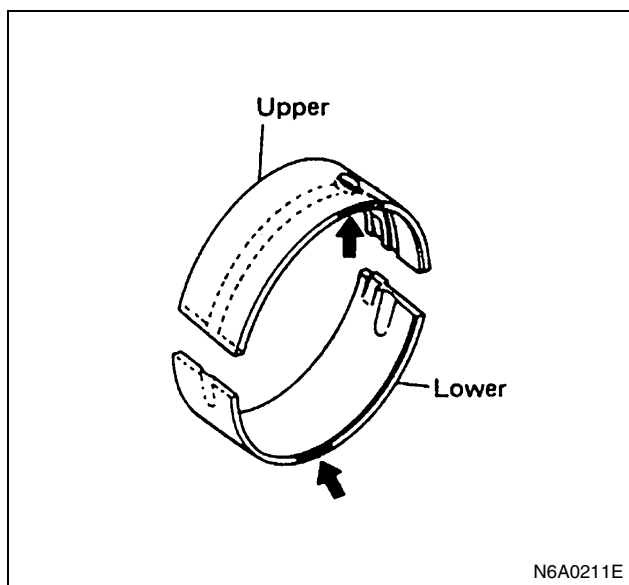
The clearance between the crankshaft journal and the bearing must be the same for each position after installation of the crankshaft and the crankshaft bearings.

Example:

2	1	2	2	1
↑	↑	↑	↑	↑
No.1 Journal	No.2 Journal	No.3 Journal	No.4 Journal	No.5 Journal



Crankshaft Bearing Combination (Reference)					mm (in)
Bearing Housing		Crankshaft Journal No.1, 2, 4, 5		Crankshaft Bearing	Oil Clearance
Grade Mark	Diameter	Grade Mark	Diameter	Color Code	
1	87.000 — 87.009 (3.4252 — 3.4255)	1	81.905 — 81.915 (3.2246 — 3.2250)	Black	0.039 — 0.070 (0.0015 — 0.0028)
		2	81.916 — 81.925 (3.2250 — 3.2254)	Brown	0.037 — 0.068 (0.0015 — 0.0027)
2	87.010 — 87.019 (3.4256 — 3.4259)	1	81.905 — 81.915 (3.2246 — 3.2250)	Blue	0.041 — 0.072 (0.0016 — 0.0028)
		2	81.916 — 81.925 (3.2250 — 3.2254)	Black	0.039 — 0.070 (0.0015 — 0.0028)



Crankshaft Bearing Combination (Reference)					mm (in)
Bearing Housing		Crankshaft Journal No.3		Crankshaft Bearing	Oil Clearance
Grade Mark	Diameter	Grade Mark	Diameter	Color Code	
1	87.000 — 87.009 (3.4252 — 3.4255)	1	81.890 — 81.900 (3.2240 — 3.2244)	Black	0.053 — 0.084 (0.0021 — 0.0033)
		2	81.901 — 81.910 (3.2244 — 3.2248)	Brown	0.051 — 0.082 (0.0020 — 0.0032)
2	87.010 — 87.019 (3.4256 — 3.4259)	1	81.890 — 81.900 (3.2240 — 3.2244)	Blue	0.055 — 0.086 (0.0022 — 0.0034)
		2	81.901 — 81.910 (3.2244 — 3.2248)	Black	0.053 — 0.084 (0.0021 — 0.0033)

Crankpin and Connecting Rod Bearing Clearance

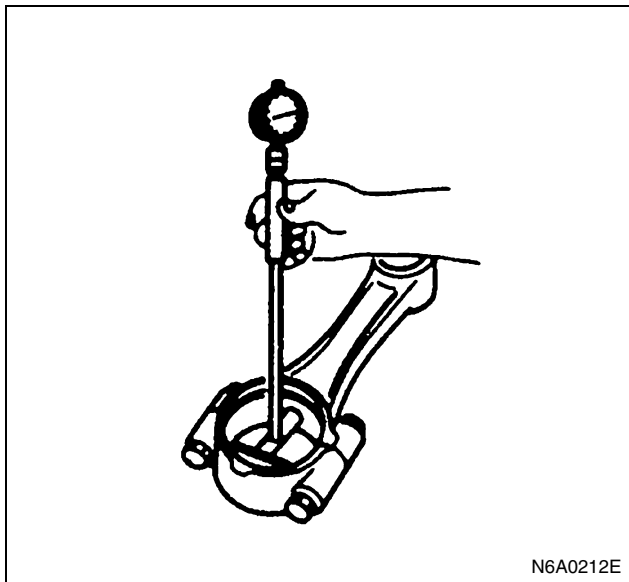
1. Clean the crankshaft, the connecting rod, the bearing cap, and the bearings.
2. Install the bearing to the connecting rod and the bearing cap.
3. Apply a coat of molybdenum disulfide grease to the bearing cap bolt threads and setting faces.
4. Prevent the connecting rod from moving.
5. Tighten the bearing cap to the specified torque.

Tighten:

Connecting rod bearing cap bolt to

- 1st step: 39 N·m (4.0 kg·m / 29 lb·ft)
 - 2nd step: 60°
 - 3rd step: 30°
6. Use the dial indicator to measure the connecting rod bearing inside diameter.

Crankpin and Connecting Rod Bearing Clearance		mm (in)
Standard	Limit	
0.036 — 0.077 (0.0014 — 0.0030)	0.10 (0.004)	



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7. If the clearance between the measured bearing inside diameter and the crankpin exceeds the specified limit, the bearing and/or the crankshaft must be replaced or reground. (Except 4HE1-TC)
8. Remove the bearing cap and the bearings.

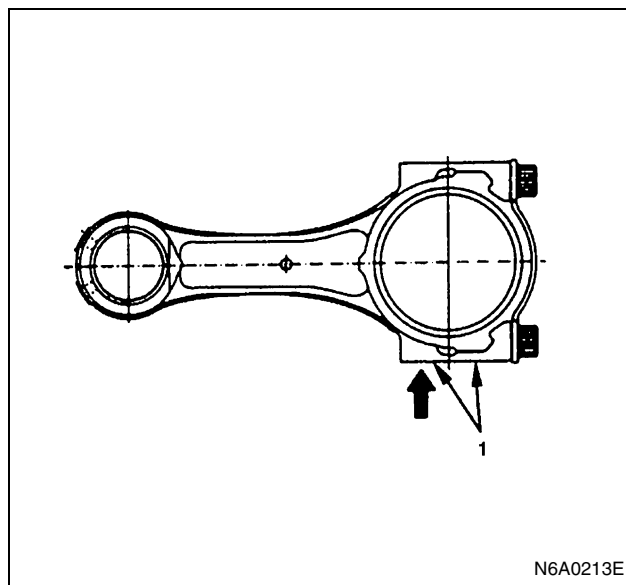
Undersized Connecting Rod Bearing Availability		mm (in)
0.25 (0.01)	0.50 (0.02)	

Connecting Rod Bearing Selection

Refer to the following table when installing or replacing the connecting rod bearings.

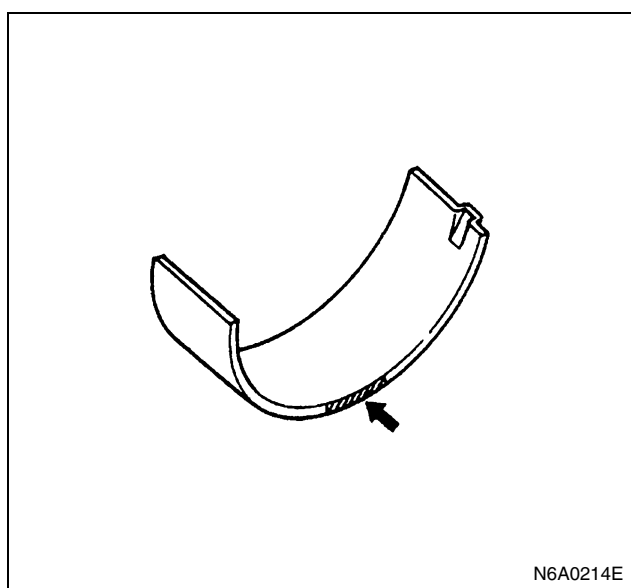
Pay close attention to the size mark on the big end of the connecting rod.

Do not confuse the size mark on the big end of connecting rod with the alignment cylinder No. (1) mark.



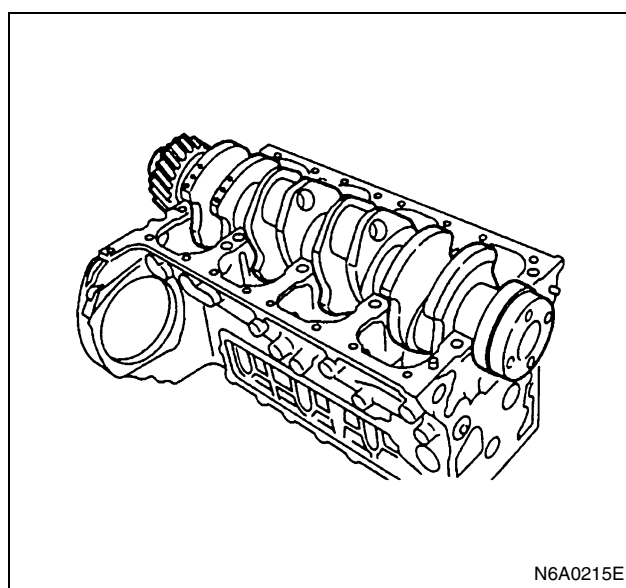
N6A0213E

Connecting Rod Bearing Combination					mm (in)
Engine Model	Connecting Rod Big End		Crankpin	Connecting Rod Bearing	Oil Clearance
	Grade Mark	Diameter	Diameter	Color Code	
4HF1 4HF1-2 4HG1 4HG1-T	A	69.985 — 69.992 (2.7553 — 2.7556)	65.902 — 65.992 (2.5946 — 2.5954)	Green	0.036 — 0.077 (0.0014 — 0.0030)
	B	69.993 — 70.000 (2.7556 — 2.7559)	65.902 — 65.922 (2.5946 — 2.5954)	Yellow	0.036 — 0.070 (0.0014 - 0.0030)
4HE1-TC	A	77.985 — 77.992 (3.0703 — 3.0705)	72.902 — 72.922 (2.8702 — 2.8709)	Green	0.037 — 0.077 (0.0015 — 0.0030)
	B	77.993 — 78.000 (3.0706 — 3.0709)		Yellow	

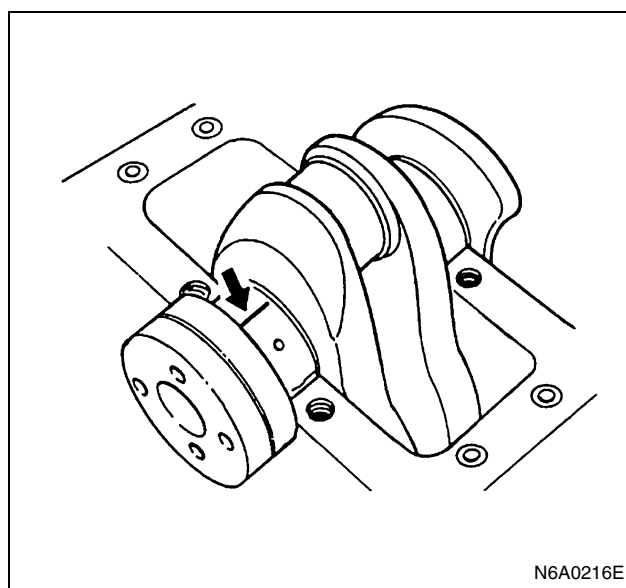


Clearance Measurements (With Plastigage) Crankshaft Journal and Bearing Clearance

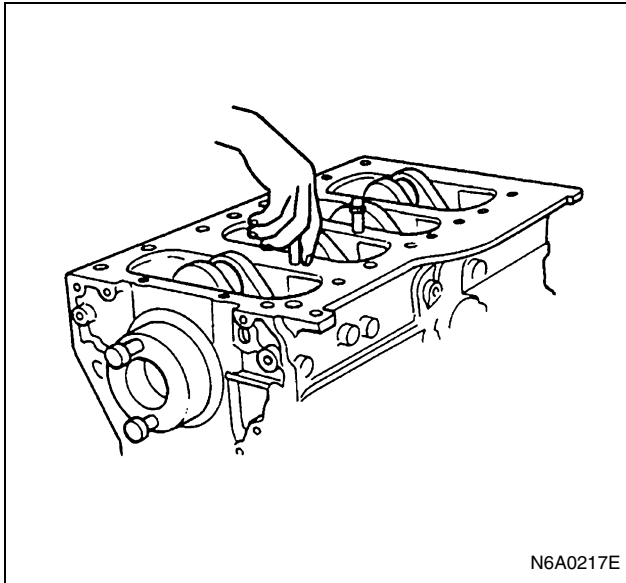
1. Clean the cylinder body and crankcase, the journal bearing fitting surface, and the journal bearings.
2. Install the bearings to the cylinder body and crankcase.
3. Carefully place the crankshaft on the bearings.
4. Rotate the crankshaft approximately 30 degrees to seat the bearing.



5. Place the Plastigage (arrow) over the crankshaft journal across the full width of the bearing.



6. Install the crankcase to the cylinder body.

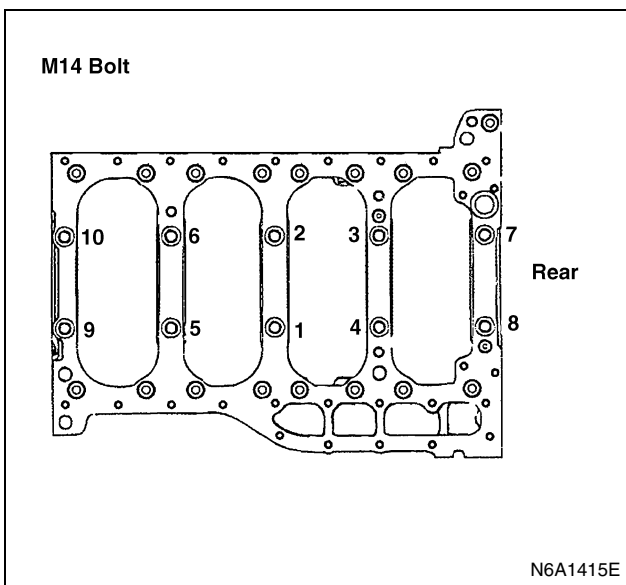


7. Tighten the crankcase to the specified torque in the numerical order shown in the illustration.

Tighten:

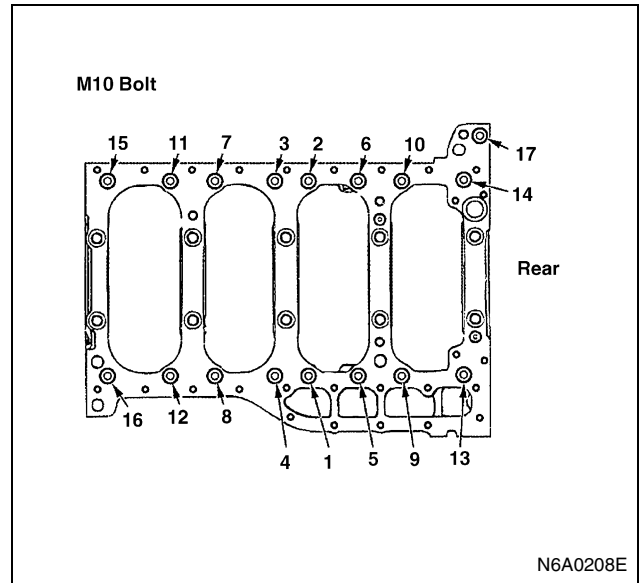
Crankcase bolt (M14: (1) — (10)) to

- 1st step: 98 N·m (10 kg·m / 72 lb·ft)
- 2nd step: 132 N·m (13.5 kg·m / 98 lb·ft)
- 3rd step: 30 — 60°



Tighten:

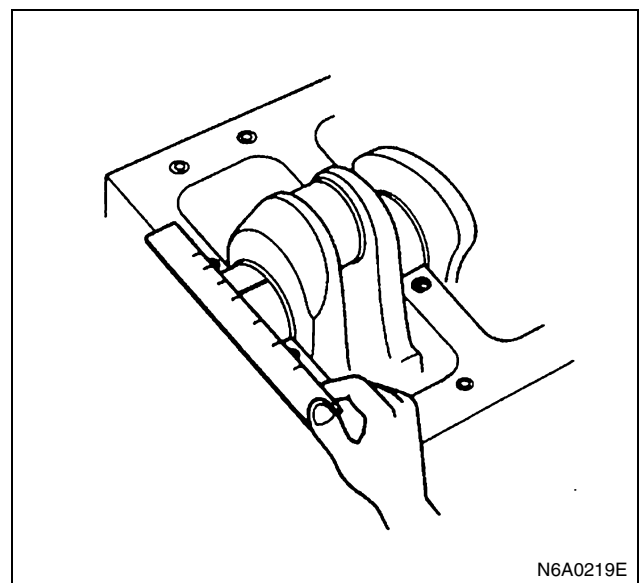
Crankcase bolt (M10: (1) — (17)) to 3.9 ± 0.7 N·m (28 ± 5 kg·m / 38 ± 7 lb·ft)



Do not allow the crankshaft to turn during bearing cap installation and tightening.

8. Remove the bearing beam and the crankcase with bearings.
9. Compare the width of the Plastigage attached to either the crankshaft or the bearing with the scale printed on the Plastigage container.

Crankshaft Journal and Bearing Clearance		mm (in)
	Standard	Limit
No.1, 2, 4 and 5 Journal	0.037 — 0.072 (0.0015 — 0.0028)	0.11 (0.0043)
No.3 Journal	0.051 — 0.086 (0.0020 — 0.0034)	0.11 (0.0043)



10. If the measured value exceeds the limit, perform the following additional steps.

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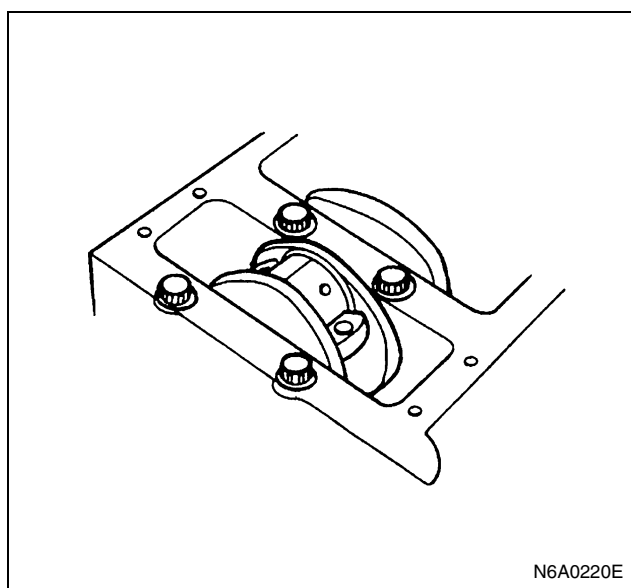
- Use a micrometer to measure the crankshaft outside diameter.
- Use an inside dial indicator to measure the bearing inside diameter.
If the crankshaft journal and bearing clearance exceeds the limit, the crankshaft and/or the bearing must be reground (Except 4HE1-TC) or replaced.

Undersized Crankshaft Journal Bearing Availability (Except 4HE1-TC)		mm (in)
0.25 (0.01)	0.50 (0.02)	

11. Remove the crankshaft and bearings.

Crankpin and Connecting Rod Bearing Clearance

1. Clean the crankshaft, the connecting rod, the bearing cap, and the bearings.
2. Install the bearing to the connecting rod and the bearing cap.
Do not allow the crankshaft to move when installing the bearing cap.
3. Prevent the connecting rod from moving.
4. Attach the Plastigage to the crankpin.
Apply engine oil to the Plastigage to keep it from falling.



5. Apply a coat of molybdenum disulfide grease to the bearing cap bolt threads and setting faces.
6. Install the bearing cap and tighten it to the specified torque.
Do not allow the connecting rod to move when installing and tightening the bearing cap.

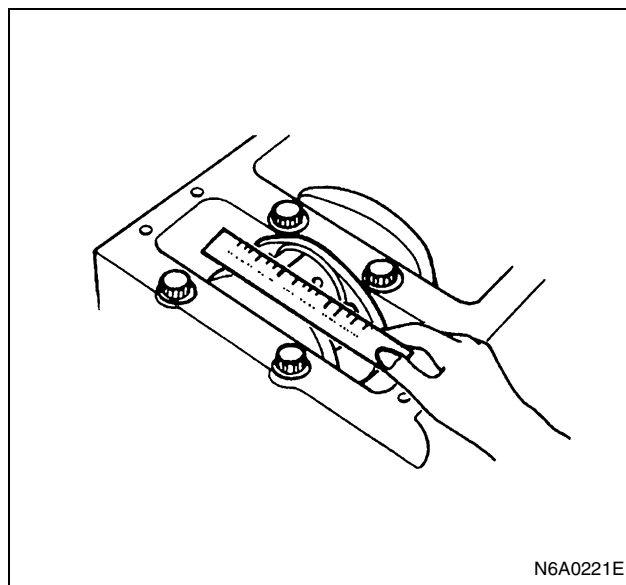
Tighten:

Connecting rod bearing cap bolt to

- 1st step: 39 N·m (4.0 kg·m / 29 lb·ft)
 - 2nd step: 60°
 - 3rd step: 30°
7. Remove the bearing cap.

8. Compare the width of the Plastigage attached to either the crankshaft or the bearing against the scale printed on the Plastigage container.

Crankpin and Connecting Rod Bearing Clearance		mm (in)
Standard	Limit	
0.036 — 0.077 (0.0014 — 0.0030)	0.10 (0.004)	



9. If the measured value exceeds the specified limit, perform the following additional steps.
 - Use a micrometer to measure the crankpin outside diameter.
 - Use an inside dial indicator to measure the bearing inside diameter.
If the clearance between the crankpin and the bearing exceeds the specified limit, the crankshaft and / or the bearing must be reground (except 4HE1-TC) or replaced.

Undersized Connecting Rod Bearing Availability (Except 4HE1-TC)		mm (in)
0.25 (0.01)	0.50 (0.02)	

Crankshaft Regrinding (Except 4HE1-TC)

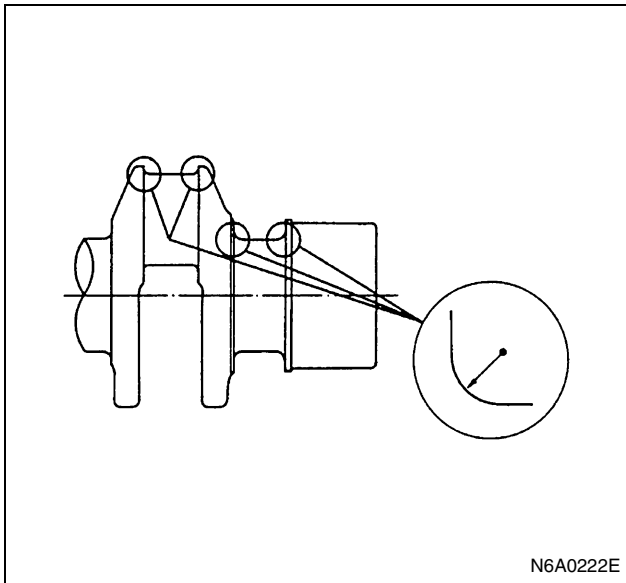
To ensure crankshaft reliability, pay close attention to the following items during and after the crankshaft journal and crankpin regrinding procedure.

Undersized Bearing Availability		mm (in)
0.25 (0.01)	0.50 (0.02)	

Crankshaft Journal and Crankpin Grinding Limit (Reference)		mm (in)
Journal	No.1, 2, 4, 5	81.405 (3.2049)
	No.3	81.390 (3.2043)
Crankpin		65.402 (2.5749)

Crankshaft Regrinding Procedure (Except 4HE1-TC)

1. Regrind the crankshaft journals and the crankpins.
2. Fillet the crankshaft journals and the crankpin radii to a minimum of $R\ 4.8 \pm 0.2\ \text{mm}$ ($0.189 \pm 0.0078\ \text{in}$). There must be no stepping around the fillet area.



3. Finish the crankshaft journals, the crankpins, and the oil port corners to a smooth surface having a chamfer radius of 1 mm (0.04 in).

Crankshaft Journal and Crankpin Roughness
0.4 μm or less

4. Check the crankshaft journal and crankpin clearance.
Refer to the "Crankshaft Journal and Bearing Clearance" and "Crankpin and Connecting Rod Bearing Clearance".
5. Check the crankshaft run-out.
Refer to the "Crankshaft Run-Out".

Caution:

The crankshaft for 4HE1-TC is applied soft nitrided surface (Tafriding). Therefore, the crankshaft for 4HE1-TC not could be ground.

Inspection Procedure for Soft Nitrided (Tafriding) Crankshaft (For 4HE1-TC)

1. Inspect the crankshaft following points.
 - Excessive wear and damage on the surface of crankshaft journals.

- Excessive wear and damage on the surface of crankpin.
- Excessive wear and damage on the oil seal fitting surface.
- Inspect the oil ports for obstructions.

2. Inspect the crankshaft soft nitrided surface (Tafriding). The soft nitrided crankshaft has been applied to increase crankshaft strength.

Because of this, it is not possible to regrind the crankshaft surfaces.

1) Inspection conditions.

- Remove the oil and other material on the crankshaft inspection area.
- The portion to be tested must be held horizontally so as not let the test solution flow.
- Test liquid should not be applied to the approximately 10 mm (0.39 in) area around the oil port (2).

2) Inspection method

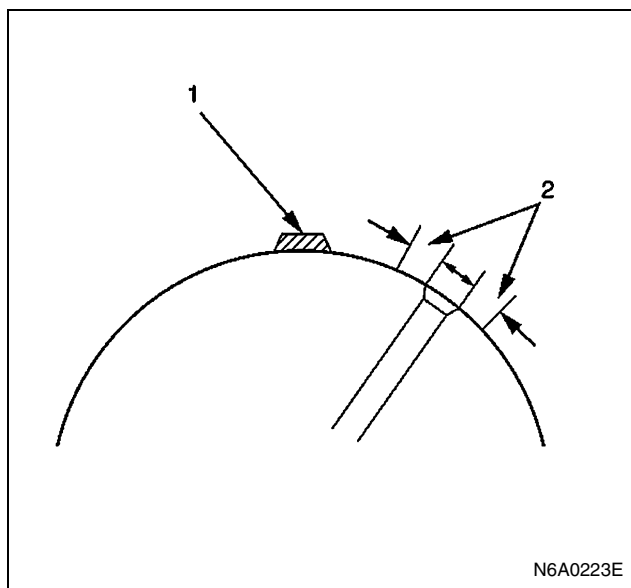
- Use an organic cleaner to thoroughly clean the crankshaft. There must be no traces of oil the surfaces to be inspected.
- Prepare a 5 — 10 percent solution of ammonium cupric chloride (dissolved in distilled water).
- Use a syringe to apply the solution (1) to the surface to be inspected. Hold the surface to be inspected perfectly horizontal to prevent the solution from running.

3) Judgement

- Wait for thirty to forty seconds. If there is no discoloration after thirty to forty seconds, the crankshaft is usable. If discoloration appears (the surface being tested will become the color copper), the crankshaft must be replaced.
- Steam clean the crankshaft surface immediately after completing the inspection.

Notice:

The ammonium cupric chloride solution is highly corrosive. Because of this, it is imperative that the surfaces being inspected be cleaned immediately after completing the inspection.



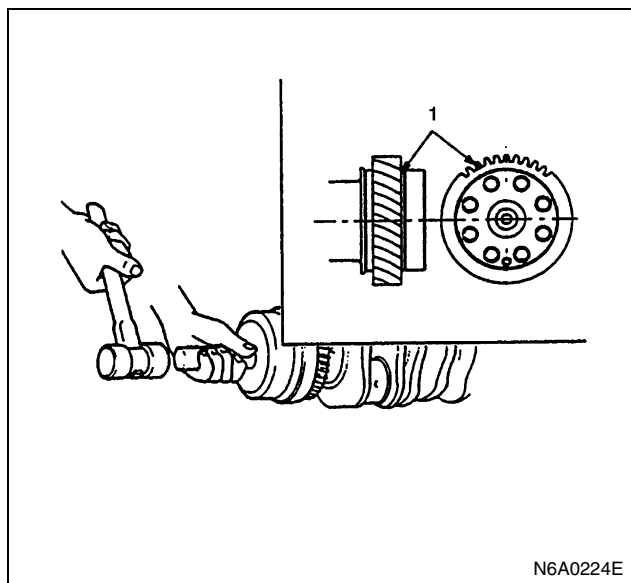
Reassembly

1. Crankshaft
2. Crankshaft Gear
 - 1) Use a piston heater to heat the crankshaft gear to 170 — 250°C (338 — 482°F).
 - 2) With the alignment mark "S" on the side of the crankshaft gear turned outward, align the groove on the gear side with the crankshaft pin position and hammer it in with a crankshaft gear installer until it hits the bottom.

Caution:

When hammered in with the gear slanted, the crankshaft gear may be caught in the middle and cannot be hammered in fully. Hammer it in quickly enough not to allow a shaft line along the gear and the crankshaft to slant.

Crankshaft Gear Installer: 8-9439-6819-0



Legend

1. Alignment mark

3. Crankshaft Bearing Upper

When replacing the crankshaft or the crankshaft bearing with a new one, select the crankshaft bearing according to the respective grades stamped on the crankshaft and the cylinder body.

Above works refer to "CRANKSHAFT" section in this manual.

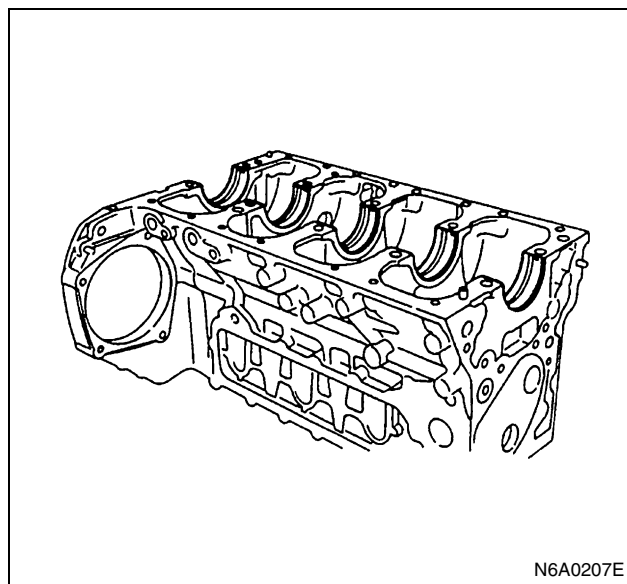
All upper bearings have oil grooves.

- 1) Carefully wipe any foreign material from the upper bearing.

Caution:

Do not apply engine oil to the bearing back faces and the cylinder body bearing fitting surfaces.

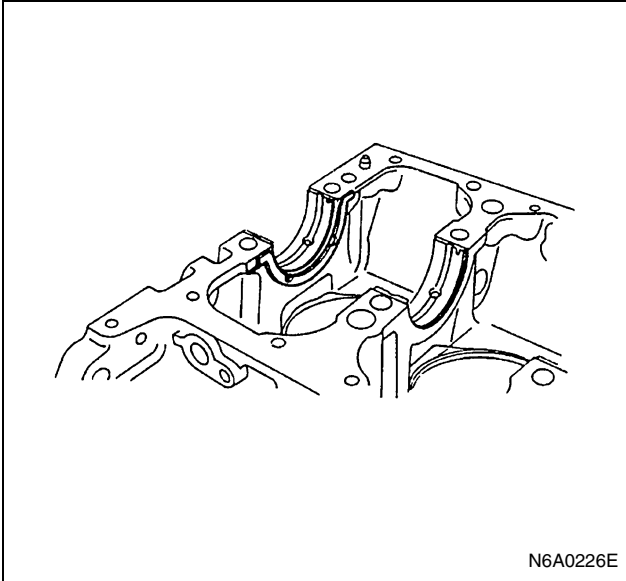
- 2) Locate the position mark applied at disassembly if the removed upper bearings are to be re-used.



4. Thrust Bearing Upper

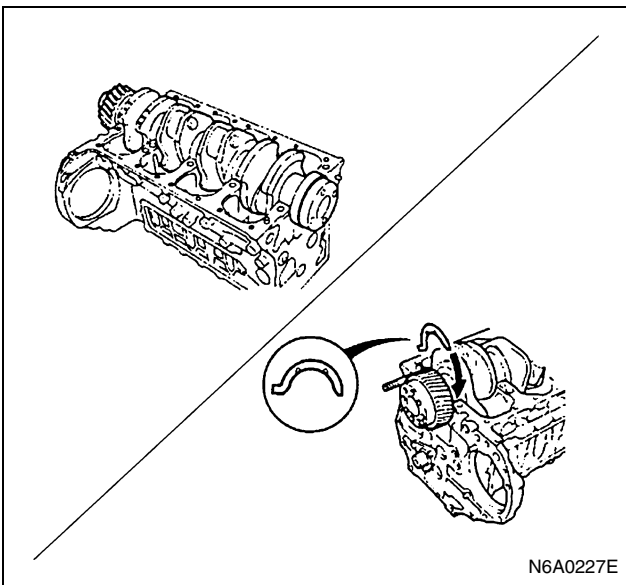
- 1) Install the thrust bearing upper to the front side of the cylinder body No.5 journal. At this time, the thrust bearing upper may be pasted to the cylinder body with grease. However, wipe off any excessive grease clean.

- 2) The thrust bearing oil grooves must be facing the sliding faces.



5. Crankshaft Assembly

- 1) Apply an ample coat of the engine oil to the crankshaft journals and the crankshaft bearing surfaces before installing the crankshaft with timing gear.
- 2) With the installed crankshaft pressed on to the rear side, install the thrust bearing upper to the rear side of the cylinder body No.5 journal.
- 3) The thrust bearing oil grooves must be facing the sliding faces.



6. Crankshaft Bearing Lower

All lower bearings does not have oil grooves.

- 1) Carefully wipe any foreign material from the lower bearing.

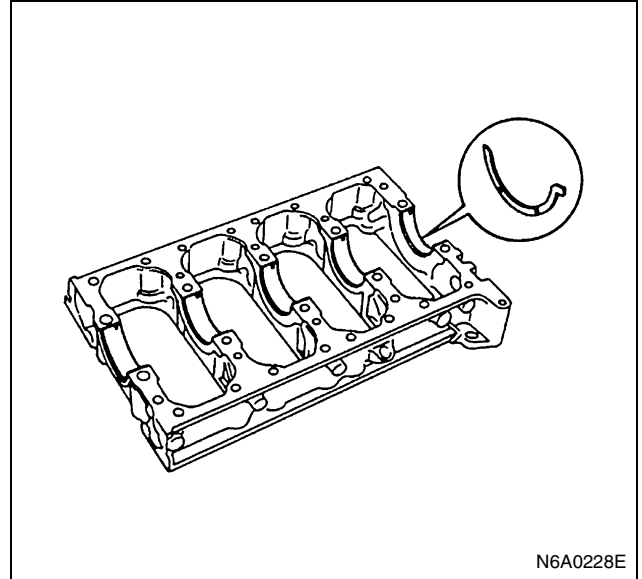
Caution:

Do not apply engine oil to the bearing back faces and the crankcase bearing fitting surfaces.

- 2) Locate the position mark applied at disassembly if the removed lower bearings are to be re-used.

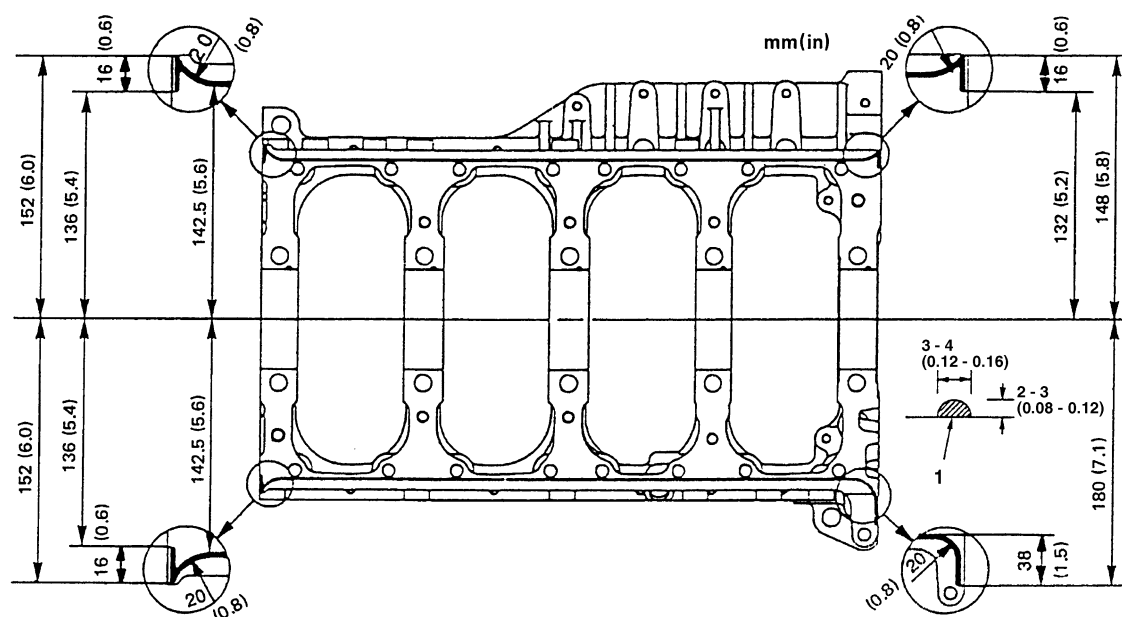
7. Thrust Bearing Lower

- 1) Install the thrust bearing lower to the rear side of the crankcase No.5 journal.
- 2) The thrust bearing oil grooves must be facing the sliding faces.



8. Crankcase

- 1) Apply a 3 mm (0.12 in) bead of recommended liquid gasket (Three Bond 1207C) or its equivalent to the crankcase upper surface as shown in the illustration.
- 2) Carefully place the crankcase on the cylinder body.
 - Install the crankcase within 20 minutes after application of liquid gasket.



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Legend

1. Liquid gasket

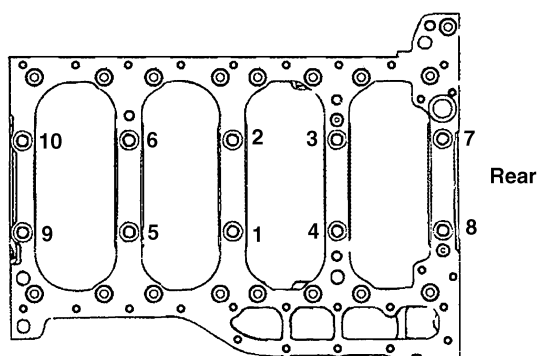
- 3) Tighten the crankcase to the specified torque in the numerical order shown in the illustration.

Tighten:

Crankcase bolt (M14: (1) — (10)) to

- 1st step: 98 N·m (10 kg·m / 72 lb·ft)
- 2nd step: 132 N·m (13.5 kg·m / 98 lb·ft)
- 3rd step: 30 — 60°

M14 Bolt

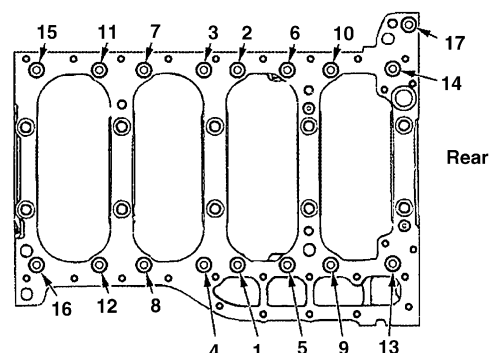


N6A1415E

Tighten:

Crankcase bolt (M10: (1) — (17)) to 37 N·m (3.8 kg·m / 27 lb·ft)

M10 Bolt

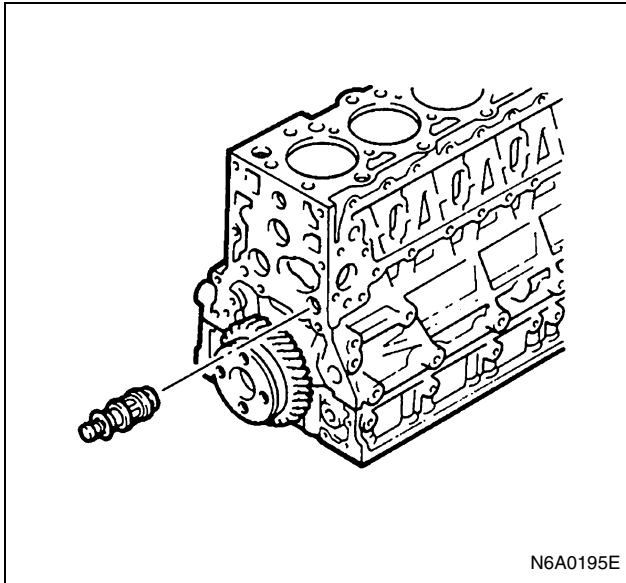


N6A0208E

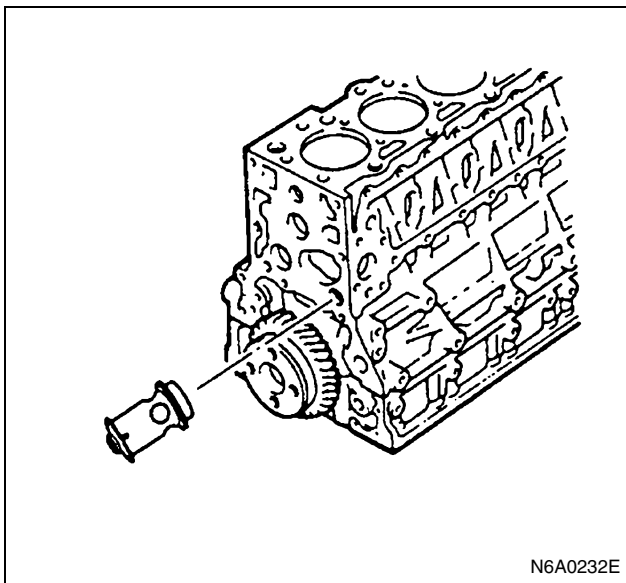
Angle gauge: 5-8840-0266-0

9. Piston and Connecting Rod Assembly
10. Connecting Rod Lower Bearing

11. Connecting Rod Cap Assembly
Above works refer to "PISTON AND CONNECTING ROD" section in this manual.
12. Oil Pump Assembly
13. Idle Gear A
14. Flywheel Housing
15. Power Steering Pump Idle Gear
16. Power Steering Pump Idle Gear Cover
Above works refer to O"IL PUMP" section in this manual.
17. Oil Thermo Valve (4HF1, 4HF1-2, 4HG1, 4HG1-T)
Insert the oil thermo valve into the cylinder body.



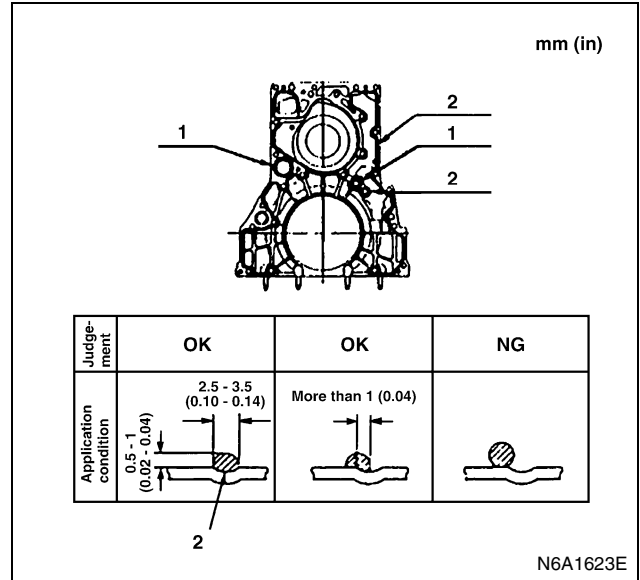
18. Bypass Valve (4HE1-TC)
Insert the bypass valve into the cylinder body.



19. Front Retainer
 - 1) Carefully wipe any foreign material from the cylinder body front face.
 - 2) Apply 2.5 — 3.5 mm (0.10 — 0.14 in) bead of the recommended liquid gasket (Three Bond 1207C) or its equivalent on the groove of the

front retainer fitting surface shown in the illustration.

- 3) Install the O-rings (2 pieces) to the front retainer.
 - Install the front retainer within 7 minutes after application of liquid gasket.
 - For the dislocation of liquid gasket, refer to the illustration.



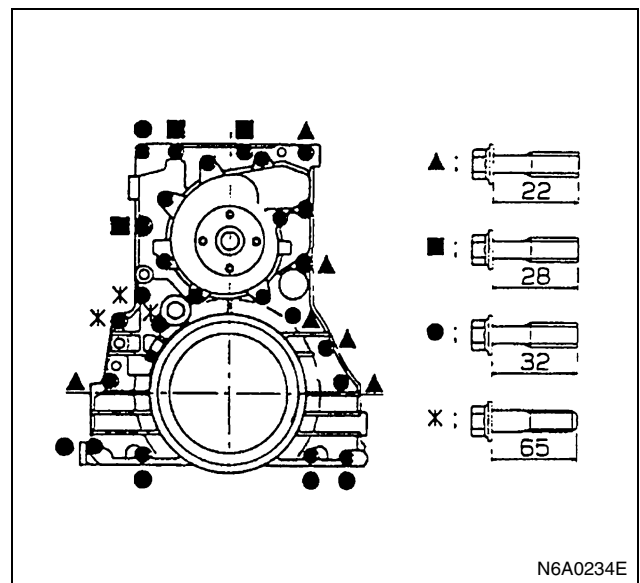
Legend

1. O-ring
2. Liquid gasket

- 4) Align the cylinder body knock pins with the front retainer knock pin holes.

Tighten:

Front retainer bolt to 24 N·m (2.4 kg·m / 17 lb·ft)



20. Water Pump Assembly
21. Water Pump Pulley
22. Oil Pump Strainer

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23. Oil Pan

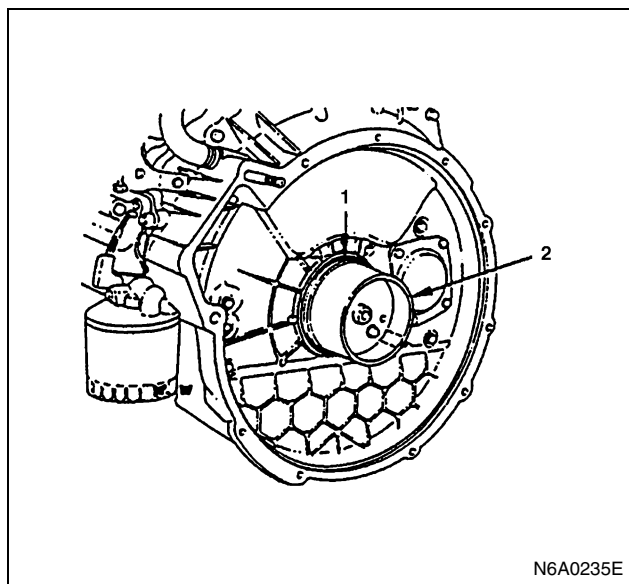
24. Spacer Rubber

Above works refer to "CYLINDER BLOCK" section in this manual.

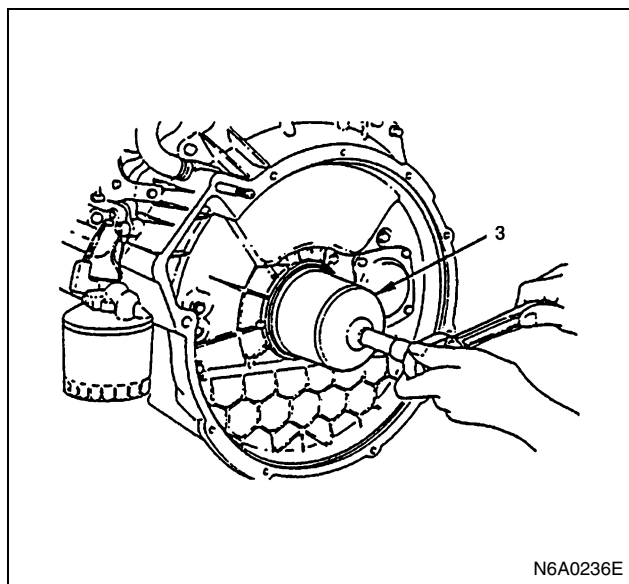
25. Crankshaft Rear Slinger

Press in the slinger using oil seal setting tool kit.

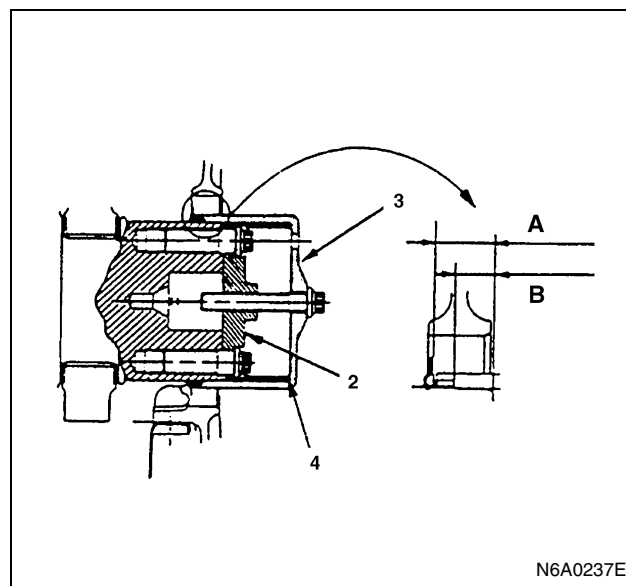
- 1) Insert the slinger (1) into the end of the adapter (2) and install the adapter on the crankshaft.



- 2) Cover the sleeve (3) and tighten the bolt until the sleeve comes to contact the adapter stopper (4).



- 3) Make sure of measurements specified in the illustration as well as of slinger deflection.
(A): 17.3 ± 0.3 mm (0.681 ± 0.012 in)
(B): 10.8 ± 0.1 mm (0.425 ± 0.004 in)

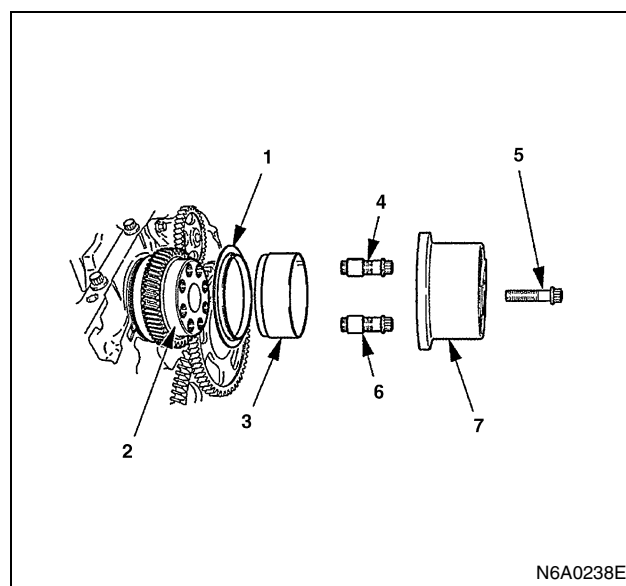


Notice:

Be sure to replace the slinger and oil seal as a set.

Oil Seal Setting Tool Kit: 5-8840-2431-0

Rear slinger and oil seal setting tools			
Part Name	Stamp	Slinger	Oil Seal
Adapter	RR	○	○
Sleeve	RR	○	○
Oil seal adapter ring	RR		○
Center bolt	—	○	○
Adapter bolt	—	○	○
Adapter bolt collar	RR	○	○

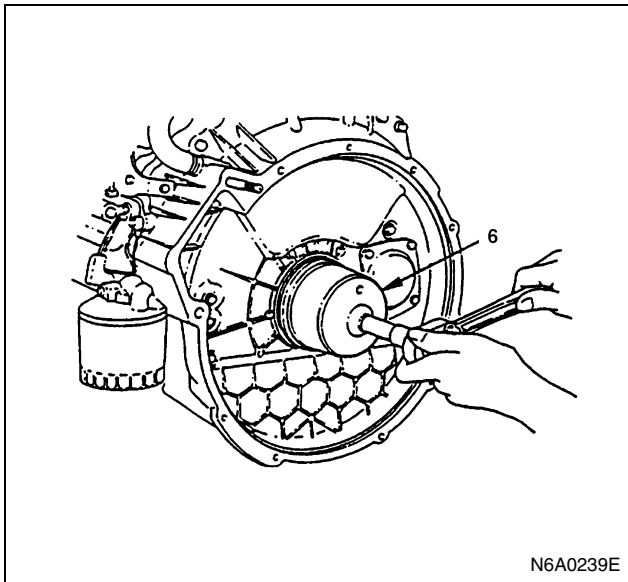


Legend

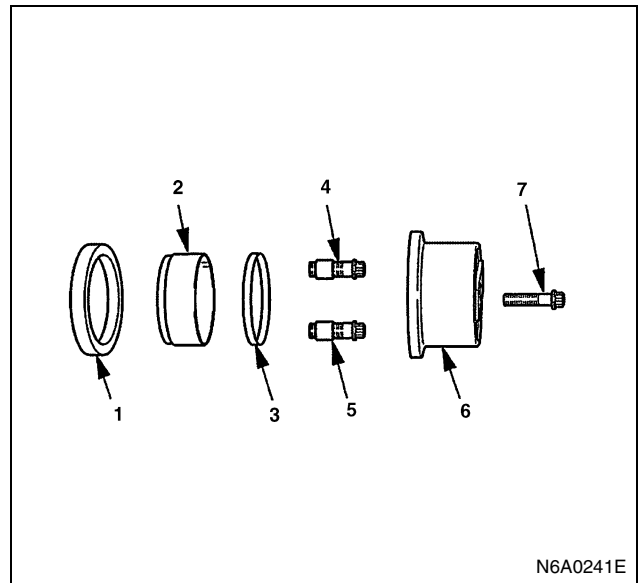
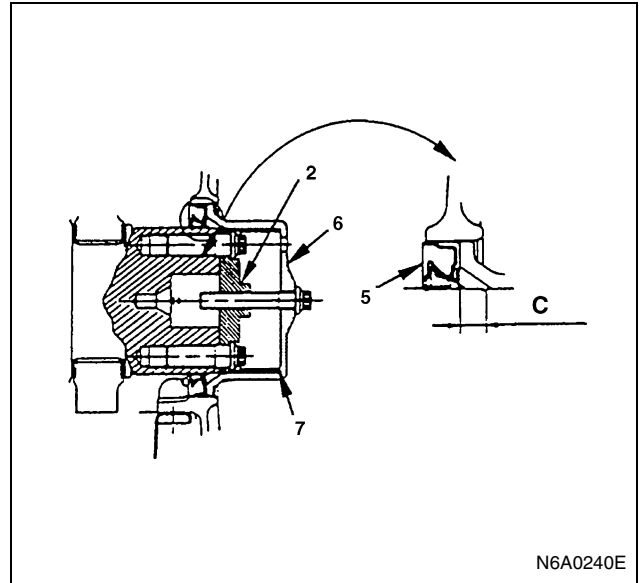
1. Slinger
2. Crankshaft
3. Adapter
4. Adapter bolt
5. Center bolt
6. Collar
7. Sleeve

26. Crankshaft Rear Oil Seal

- 1) Apply engine oil to the lip of the oil seal.
- 2) Press in the oil seal using rear oil seal setting tool kit.
- 3) Remove the slinger sleeve and insert the oil seal (5) into the adapter (2).
- 4) Install the adapter ring into the sleeve.
- 5) Install the oil seal sleeve (6) to the adapter (2) and tighten the center bolt until the sleeve comes to contact the adapter stopper (7).



- 6) With the oil seal pressed in, make sure of the measurements specified in the illustration.
(C): 7.8 ± 0.3 mm (0.307 ± 0.012 in)

**Legend**

1. Oil seal
2. Adapter
3. Ring
4. Adapter bolt
5. Collar
6. Sleeve
7. Center bolt

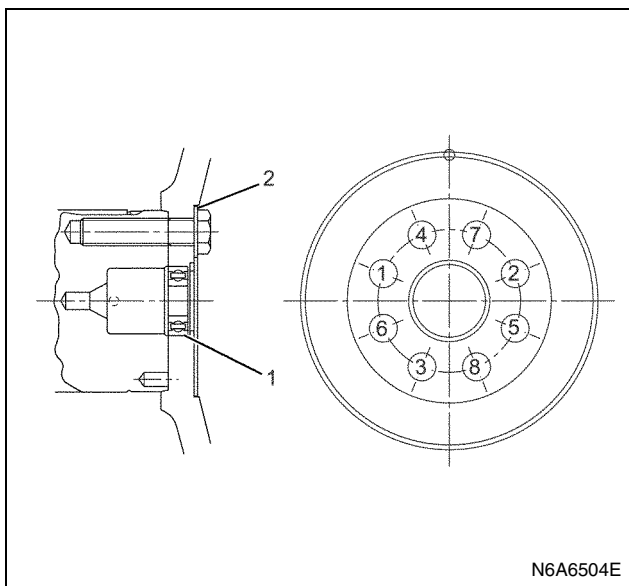
27. Flywheel Assembly

- 1) Apply molybdenum disulfide grease to the flywheel bolt threads and setting faces.
- 2) Align the flywheel with the crankshaft knock pin and temporarily tighten the flywheel bolts.
- 3) Use the crankshaft stopper to prevent the crankshaft from turning.
Crankshaft Stopper: 5-8840-2230-0
- 4) Install the washer and the flywheel bolts and tighten to the specified torque in numerical order show in the illustration.

Tighten:

Flywheel bolt to

- 1st step: 78 N·m (8.0 kg·m / 58 lb·ft)
- 2nd step: 90 — 120°



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Legend

1. Washer
2. Pilot bearing

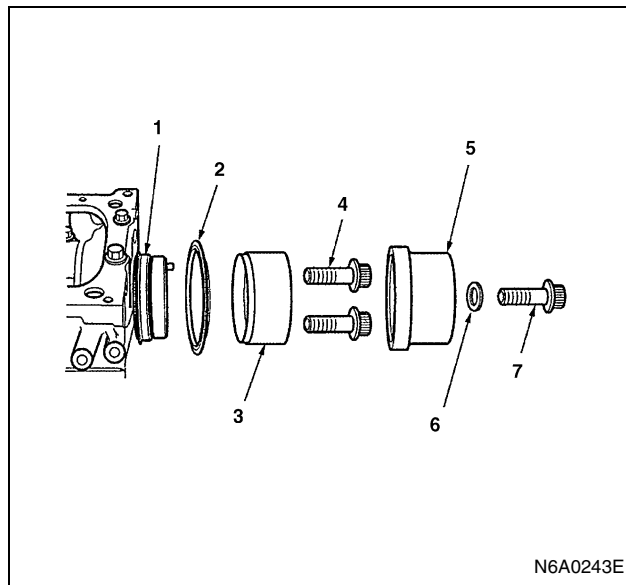
5) Remove the crankshaft stopper.

28. Crankshaft Front Slinger

Press in the slinger using the oil seal setting tool kit.

Oil Seal Setting Tool Kit: 5-8840-2431-0

Front slinger and oil seal setting tools			
Part Name	Stamp	Slinger	Oil Seal
Adapter	FT	○	○
Sleeve	FT	○	○
Oil seal adapter ring	FT		○
Center bolt	—	○	○
Adapter bolt	—	○	○

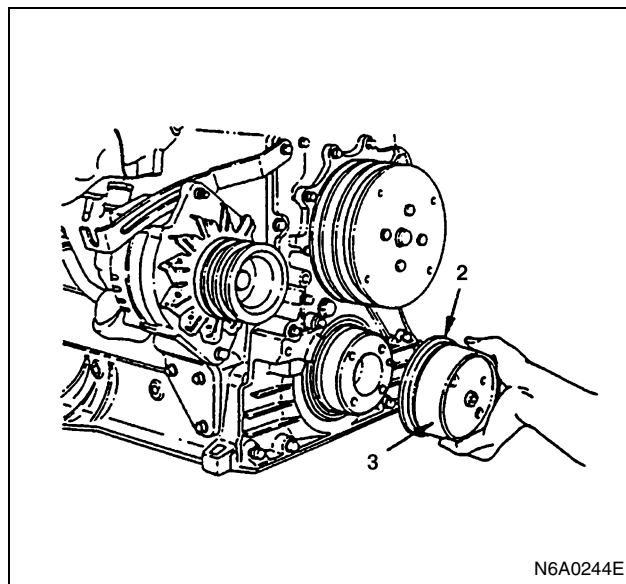


N6A0243E

Legend

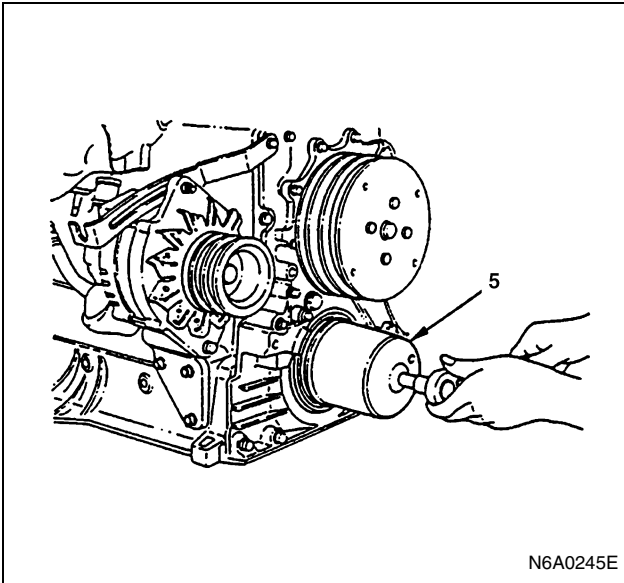
1. Crankshaft
2. Slinger
3. Adapter
4. Adapter bolt
5. Sleeve
6. Washer (5 mm (0.20 in))
7. Center bolt

- 1) Insert the slinger (2) into the end of the adapter (3) and install the adapter on the crankshaft.



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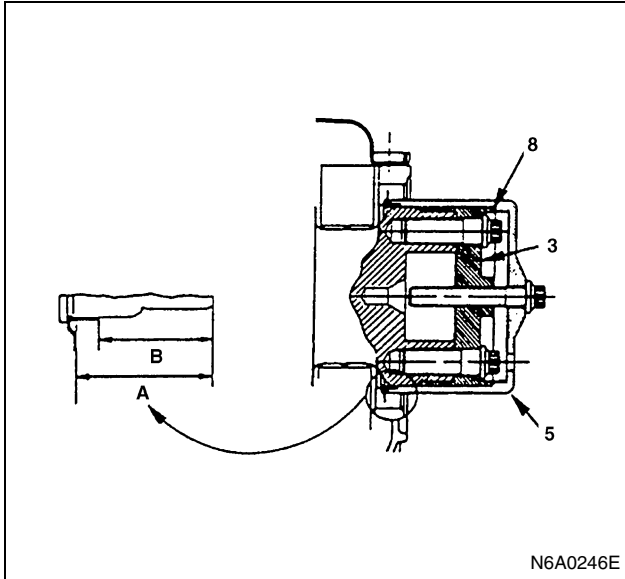
- 2) Cover the sleeve (5) and tighten the bolt until the sleeve comes to contact the adapter stopper (8).



- 3) Make sure of measurements specified in the illustration as well as of slinger deflection.
 (A): 40.5 ± 0.3 mm (1.594 ± 0.012 in)
 (B): 34.0 ± 0.1 mm (1.339 ± 0.004 in)

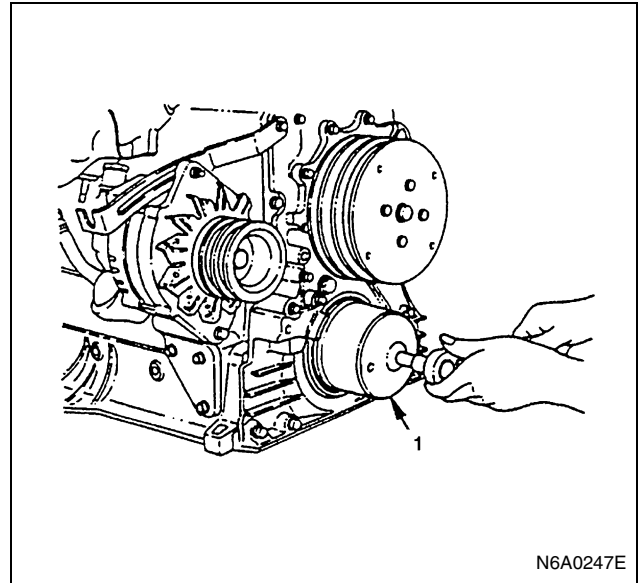
Notice:

Be sure to replace the slinger and the oil seal as a set. Use about 5mm (0.20 in) thickness plain washer on the center bolt.

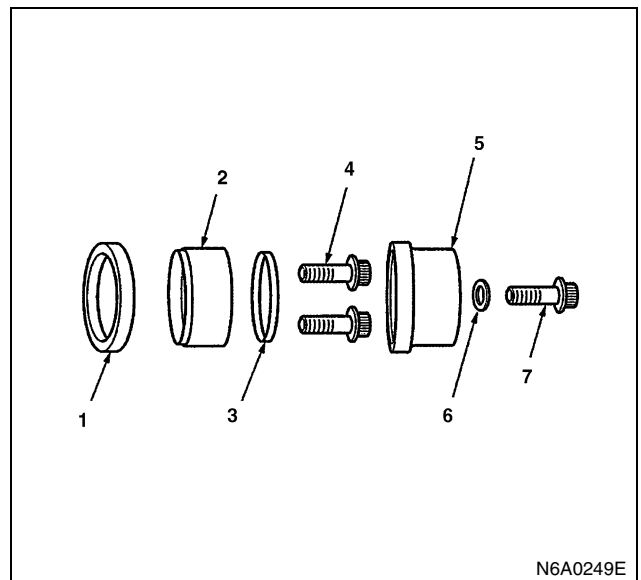
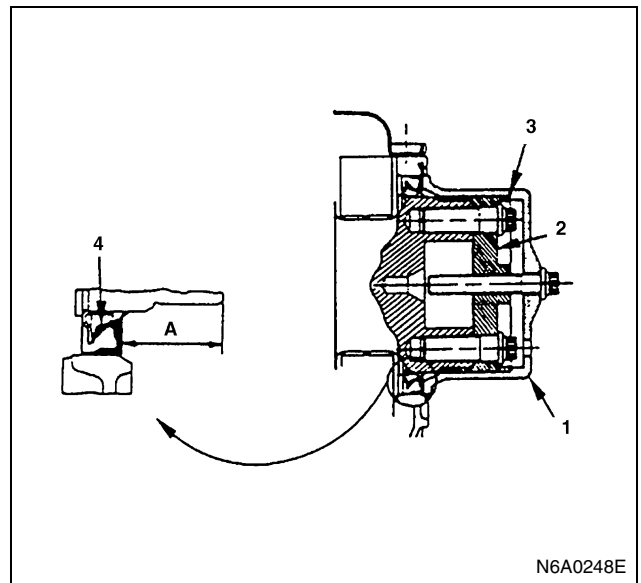


29. Crankshaft Front Oil Seal

- 1) Apply engine oil to the lip of the oil seal.
- 2) Press in the oil seal using the front oil seal setting tool kit.
- 3) Remove the slinger sleeve and insert the oil seal (4) into the adapter (2).
- 4) Install the adapter ring into the sleeve.
- 5) Install the oil seal sleeve (1) to the adapter (2) and tighten the center bolt until the sleeve comes to contact the adapter stopper (3).



- 6) Make sure of the measurements specified in the illustration.
 (A): 31 ± 0.3 mm (1.220 ± 0.012 in)



Legend

1. Oil seal
2. Adapter
3. Ring
4. Adapter bolt
5. Sleeve
6. Washer (5 mm (0.20 in))
7. Center bolt

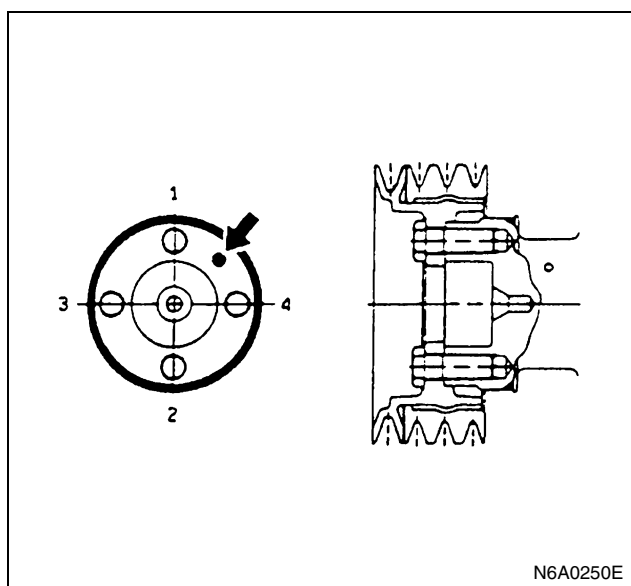
Above works refer to "CYLINDER HEAD" section in this manual.

30. Crankshaft Damper Pulley

- 1) Apply a coat of engine oil to the threads of the bolts.
- 2) Align the damper pulley with the crankshaft knock pin and tighten the bolts to the specified torque in numerical order.

Tighten:

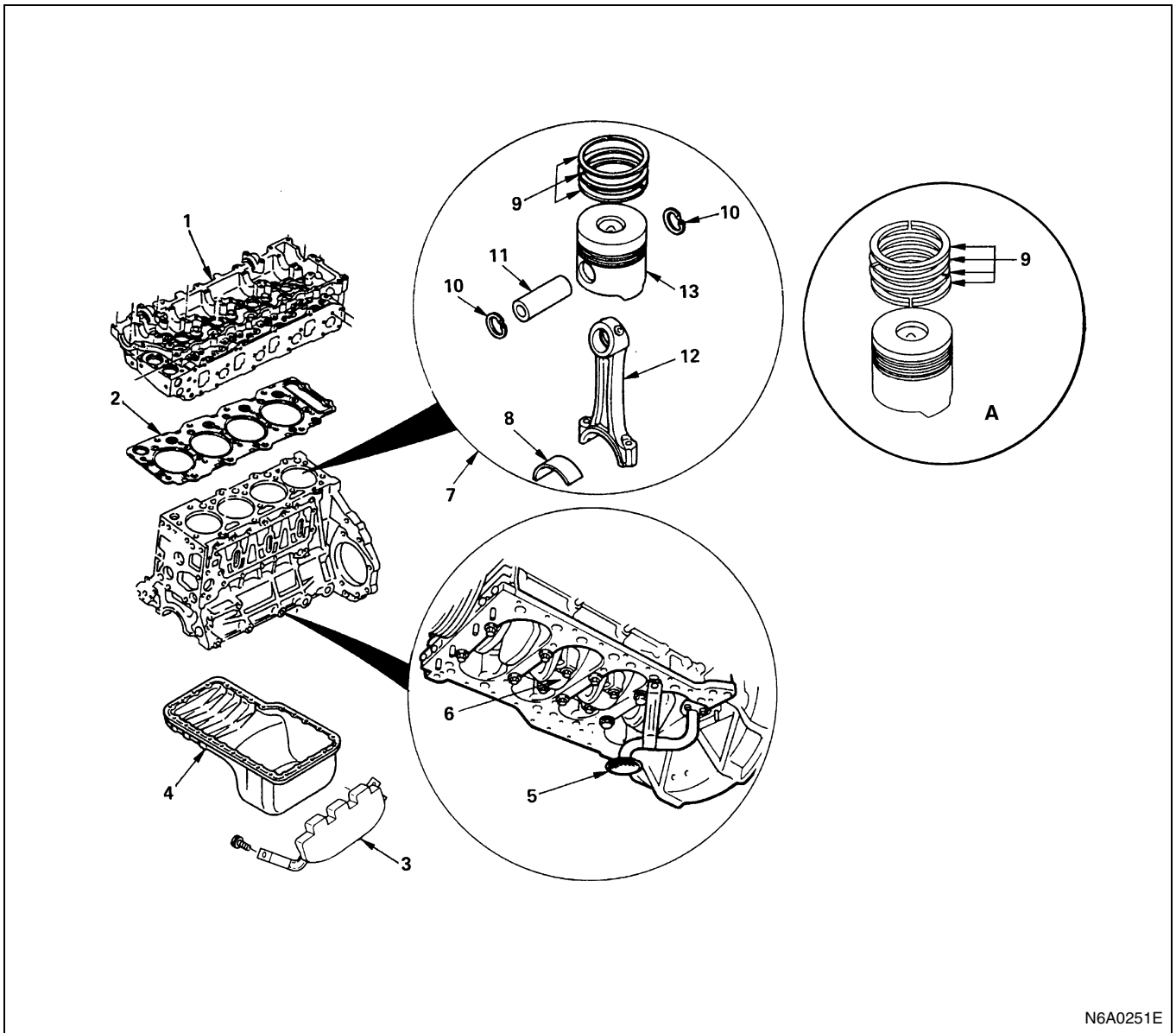
Damper pulley bolt to 200 N·m (20.4 kg·m / 147 lb·ft)



31. Generator Bracket
32. Fan Belt Adjust Plate
33. Injection Pump Assembly
34. Engine Foot
35. Generator
36. Fan Belt
37. Fan Belt Adjustment
38. Vacuum Pump Rubber Hose
39. Vacuum Pump Oil Pipe
40. Oil Filter Assembly
41. Oil Pipe
42. Engine Control Lever Assembly
43. Engine Control Wire
44. Driven Plate
45. Clutch Pressure Plate Assembly
46. Cylinder Head Gasket
- Above works refer to "CYLINDER BLOCK" section in this manual.
47. Cylinder Head Assembly

PISTON AND CONNECTING ROD

Component



N6A0251E

Legend

- | | |
|---------------------------|------------------------------|
| A. For 4HE1-TC | 7. Piston and connecting rod |
| 1. Cylinder head assembly | 8. Connecting rod bearing |
| 2. Cylinder head gasket | 9. Piston ring |
| 3. Spacer rubber | 10. Piston pin snap ring |
| 4. Oil pan | 11. Piston pin |
| 5. Oil pump strainer | 12. Connecting rod |
| 6. Connecting rod cap | 13. Piston |

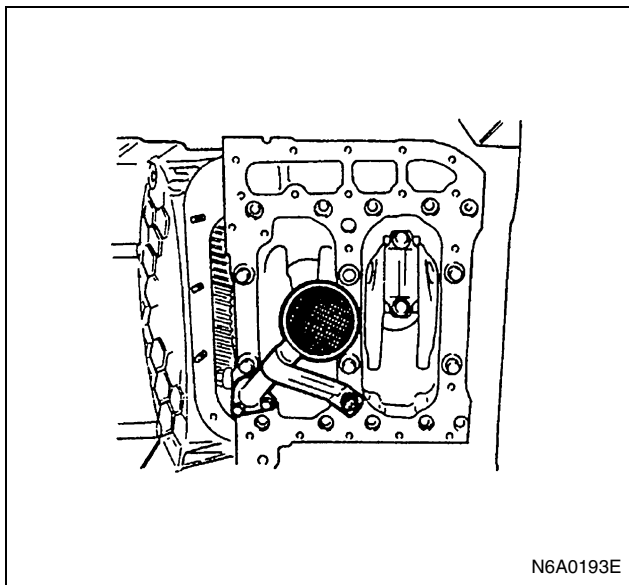
Disassembly

1. Cylinder Head Assembly
Above works refer to "CYLINDER HEAD" section in this manual.
2. Cylinder Head Gasket

Caution:

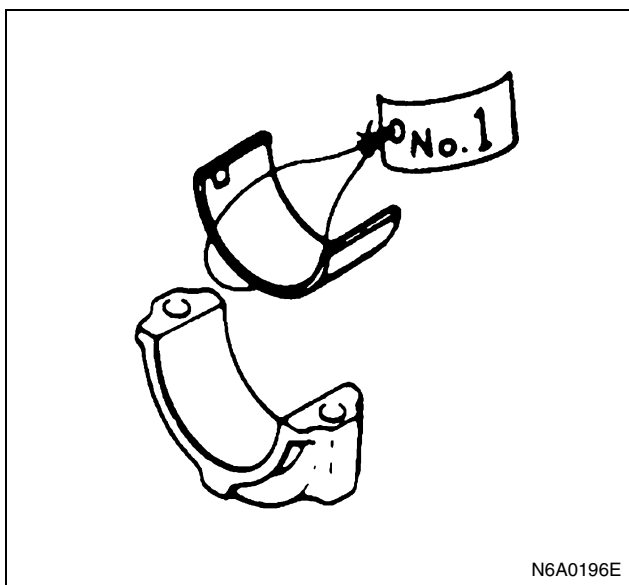
Do not reuse the cylinder head gasket.

3. Spacer Rubber
4. Oil Pan
5. Oil Pump Strainer



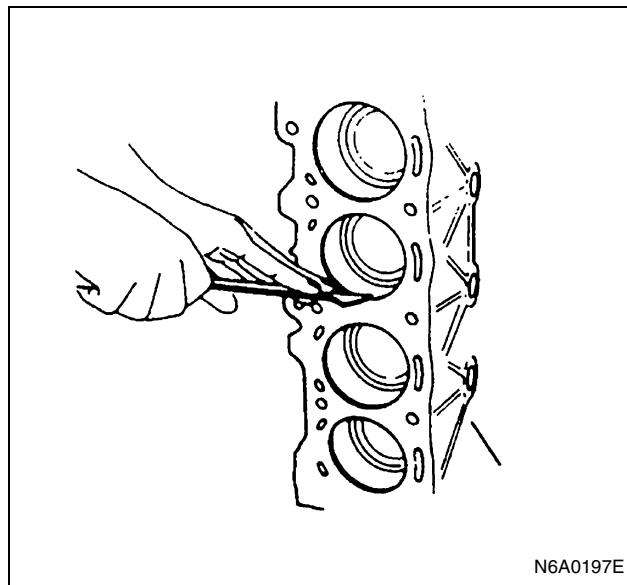
6. Connecting Rod Cap

- 1) Take out the connecting rod bearing cap bolts and remove the bearing cap with the lower bearing.
- 2) If the connecting rod lower bearings are to be reinstalled, mark their fitting positions by tagging each bearing with the cylinder number from which it was removed.



7. Piston and Connecting Rod Assembly

- 1) To facilitate smooth removal of piston, remove carbon from the upper part of the cylinder wall using a scraper or equivalent.



- 2) Remove the piston and connecting rod assembly upward by pushing on the edge of the connecting rod with a hammer handle or equivalent.
- 3) If the connecting rod bearing are to be reinstalled, mark their fitting positions by tagging each bearing with the cylinder number from which it was removed.

Caution:

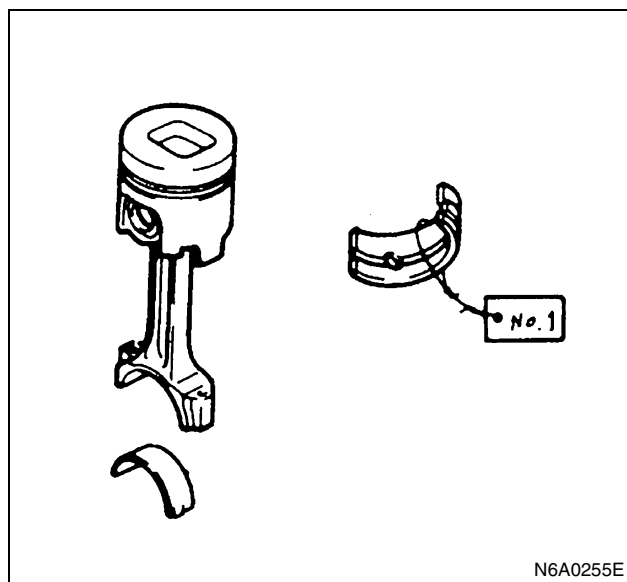
Do not bend or damage the oiling jet.

Notice:

When removing the piston and connecting rod assembly, pull the connecting rod in parallel with the cylinder bore.

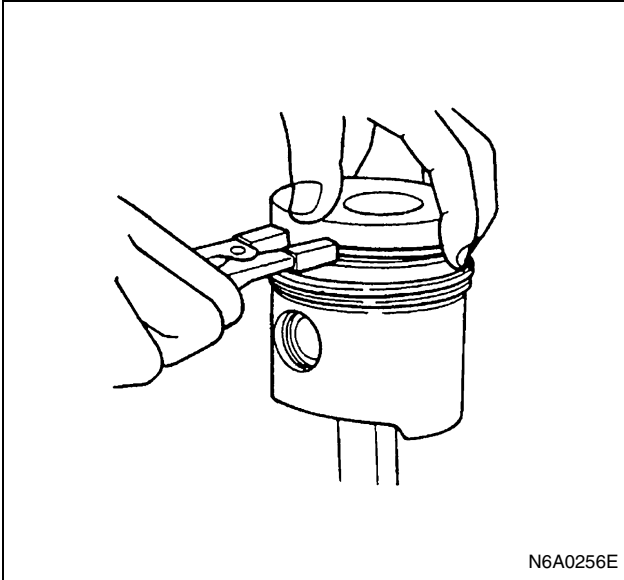
8. Connecting Rod Bearing

If the connecting rod bearings are to be reinstalled, mark their fitting positions by tagging each bearing with the cylinder number from which it was removed.



9. Piston Ring

- 1) Clamp the connecting rod in a vise.
Take care not to damage the connecting rod.
- 2) Use piston ring replacer to remove the piston rings.
Do not attempt to use some other tool to remove the piston rings. Piston ring stretching will result in reduced piston ring tension.



10. Piston Pin Snap Ring

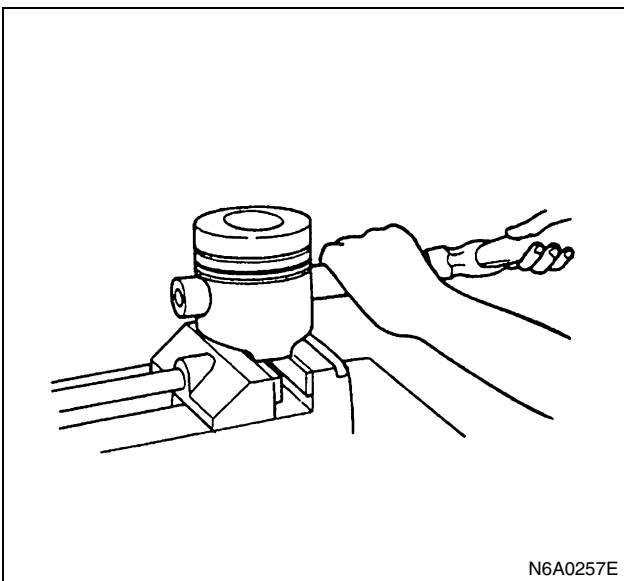
Use a pair of snap ring pliers to remove the piston pin snap rings.

11. Piston Pin

12. Connecting Rod

13. Piston

Tap the piston pin out with a hammer and a brass bar. If the pistons are to be reinstalled, mark their installation positions by tagging each piston with the cylinder number from which it was removed.



Inspection and Repair

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

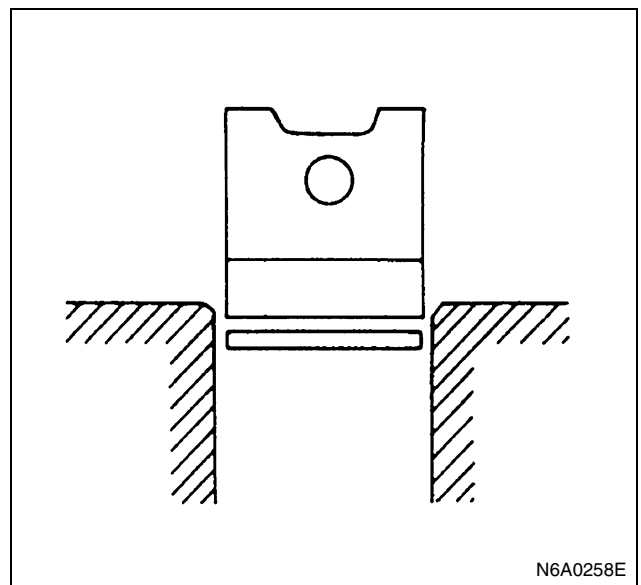
Piston Grade Selection and Cylinder Bore Measurement

Refer to the Section "CYLINDER BLOCK", Item "Cylinder Liner Bore Measurement" for details on piston grade selection and cylinder liner bore measurement.

Piston Ring

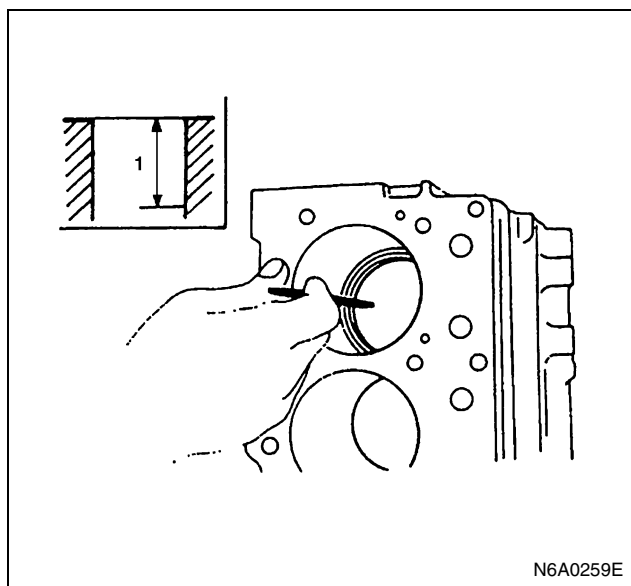
Piston Ring Gap

1. Insert the piston ring horizontally (in the position it would assume if it were installed to the piston) into the cylinder liner bore.



2. Push the piston ring into the cylinder liner bore until it reaches the point (1) where the cylinder liner bore is the smallest.
Do not allow the piston ring to slant to one side or the other. It must be perfectly horizontal.

Measuring Point	mm (in)
Approx. 150 (6)	



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3. Use a feeler gauge to measure the piston ring gap. If the measured value exceeds the specified limit, the piston ring must be replaced.

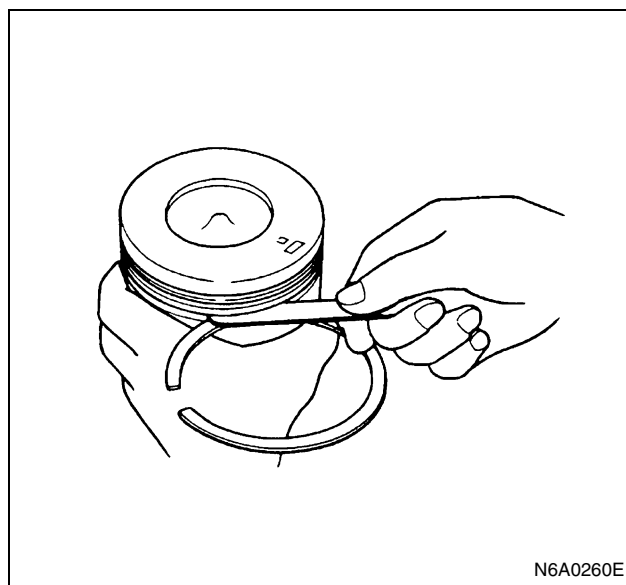
Piston Ring Gap / 4HF1 / 4HF1-2		mm (in)
	Standard	Limit
1st compression ring gap	0.24 — 0.39 (0.0094 — 0.0153)	1.50 (0.0591)
2nd compression ring gap	0.35 — 0.50 (0.0138 — 0.0197)	
Oil ring gap	0.02 — 0.40 (0.0008 — 0.0157)	

Piston Ring Gap / 4HG1 / 4HG1-T		mm (in)
	Standard	Limit
1st compression ring gap	0.24 — 0.39 (0.0094 — 0.0153)	1.50 (0.0591)
2nd compression ring gap	0.35 — 0.50 (0.0138 — 0.0197)	
Oil ring gap	0.15 — 0.35 (0.00591 — 0.0138)	

Piston Ring Gap / 4HE1-TC		mm (in)
	Standard	Limit
1st compression ring gap	0.24 — 0.40 (0.0094 — 0.0157)	1.50 (0.0591)
2nd and 3rd compression ring gap	0.30 — 0.450 (0.0118 — 0.0177)	
Oil ring gap	0.20 — 0.40 (0.0078 — 0.0157)	

Piston Ring and Piston Ring Groove Clearance

1. Use a feeler gauge to measure the clearance between the piston ring and the piston ring groove at several points around the piston.



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Piston Ring and Piston Ring Groove Clearance / 4HF1, 4HF1-2, 4HG1, 4HG1-T		mm (in)
	Standard	Limit
1st Compression Ring	0.062 — 0.092 (0.0024 — 0.0036)	0.20 (0.0079)
2nd Compression Ring	0.04 — 0.08 (0.0015 — 0.0031)	0.15 (0.0059)
Oil ring gap	0.02 — 0.06 (0.0008 — 0.0024)	

Groove Clearance / 4HE1-TC		mm (in)
	Standard	Limit
1st Compression Ring	0.09 — 0.13 (0.0035 — 0.0051)	0.20 (0.0078)
2nd and 3rd Compression Ring	0.09 — 0.13 (0.0035 — 0.0051)	
Oil ring gap	0.03 — 0.07 (0.0012 — 0.0028)	0.15 (0.0059)

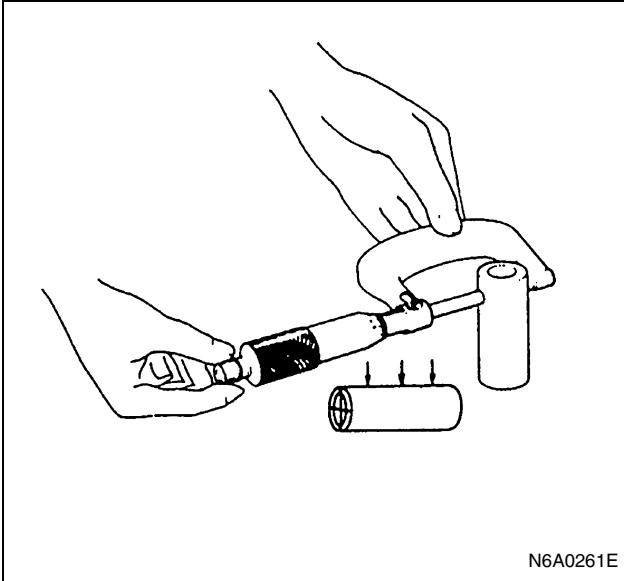
2. Visually inspect the piston ring grooves. If a piston ring groove is damaged or distorted, the piston must be replaced.

Piston Pin

Piston Pin Diameter

Use a micrometer to measure the piston pin outside diameter at several points.

If the measured value is less than the specified limit, the piston pin must be replaced.

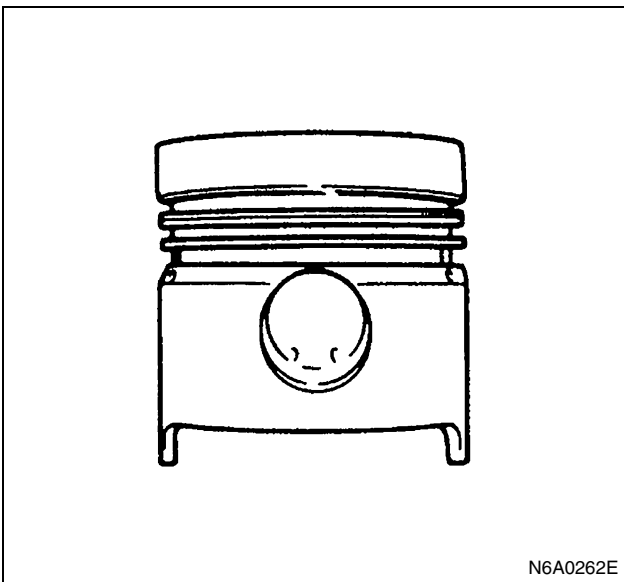


Piston Pin Diameter		mm (in)
Engine model	Standard	Limit
Except 4HE1-TC	35.995 — 36.000 (1.4171 — 1.4173)	35.970 (1.4161)
4HE1-TC	39.995 — 40.000 (1.5746 — 1.5748)	39.970 (1.5736)

Piston Pin Hole and Piston Pin Clearance

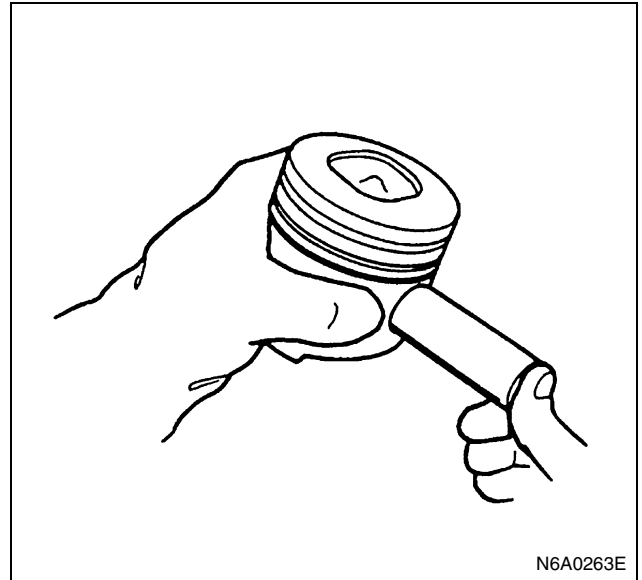
Use an inside dial indicator to measure the piston pin hole (in the piston).

Piston Pin Hole and Piston Pin Clearance		mm (in)
Standard	Limit	
0.004 — 0.017 (0.00016 — 0.00067)	0.04 (0.0016)	



If an inside dial indicator is not available, use the following procedure to check the piston pin clearance.

1. Use a piston heater to heat the piston to approximately 80 — 100°C (176 — 212°F)
2. Push strongly against the piston pin with your thumbs. The piston pin should move smoothly with little or no resistance.



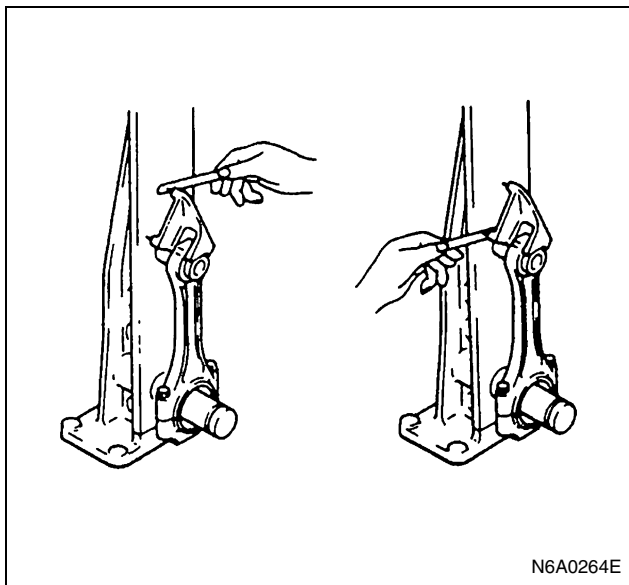
Connecting Rod

Connecting Rod Alignment

Use a connecting rod aligner to measure the distortion and the parallelism between the connecting rod big end hole and the connecting rod small end hole.

If either the measured distortion or parallelism exceeds the specified limit, the connecting rod must be replaced.

Connecting Rod Alignment			mm (in)
Per Length of 100 (3.94)			
	Standard	Limit	
Distortion	0.05 (0.002) or less	0.20 (0.008)	
Parallelism			

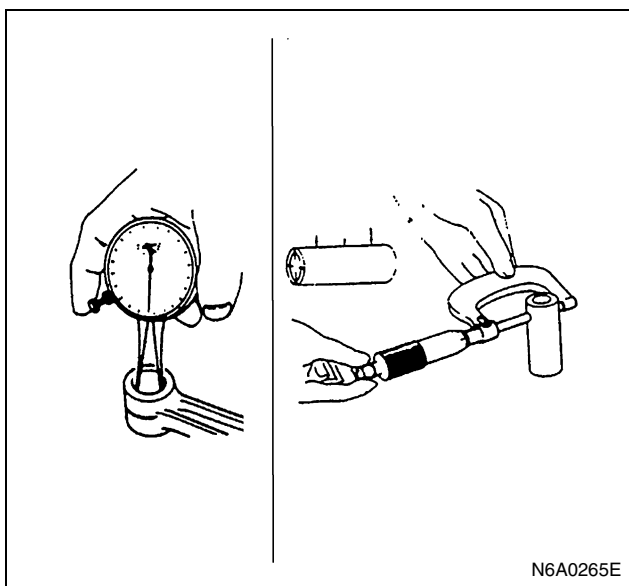


Piston Pin and Connecting rod Small End Bushing Clearance

Use a caliper calibrator and a dial indicator to measure the clearance between the piston pin and connecting rod small end bushing.

If the clearance between the piston pin and the connecting rod small end bushing exceeds the specified limit, replace the piston pin and/or the connecting rod bushing.

Piston Pin and Connecting Rod Small End Bushing Clearance		mm (in)
Standard	Limit	
0.012 — 0.027 (0.0005 — 0.0011)	0.05 (0.002)	

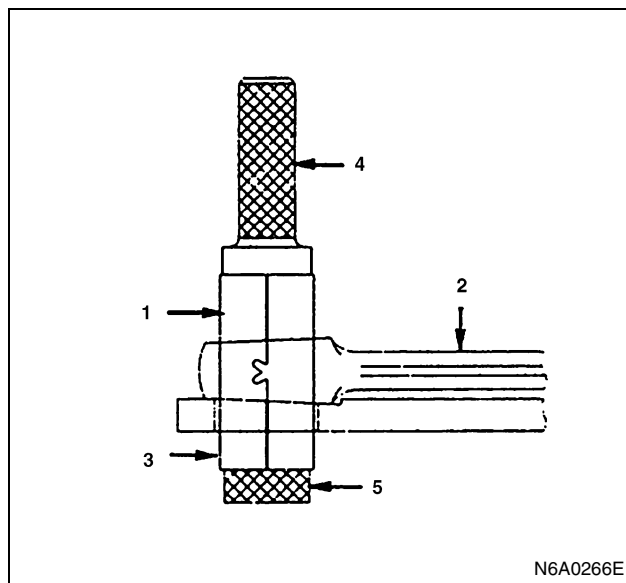


Connecting Rod Bushing Replacement

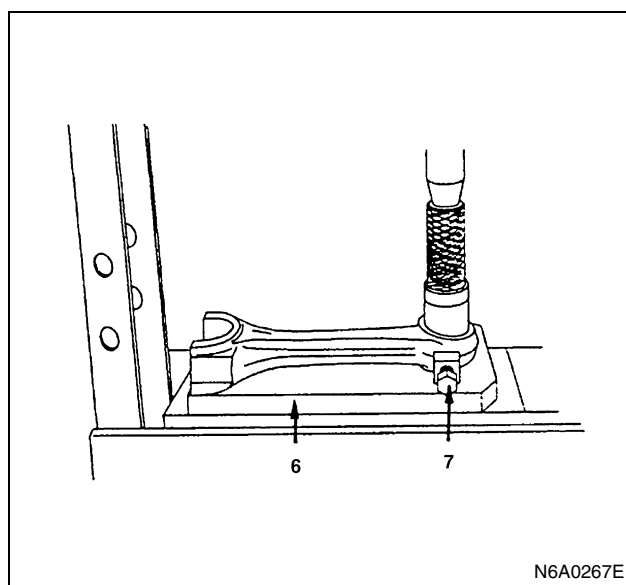
Connecting Rod Bushing Removal

1. Set the collar (1), the connecting rod (2), and the collar (3) to the setting bar (4).

- Connecting Rod Bushing Replacer: 5-8840-2340-0
2. Hand-tighten the nut (5) until there is no more gap.



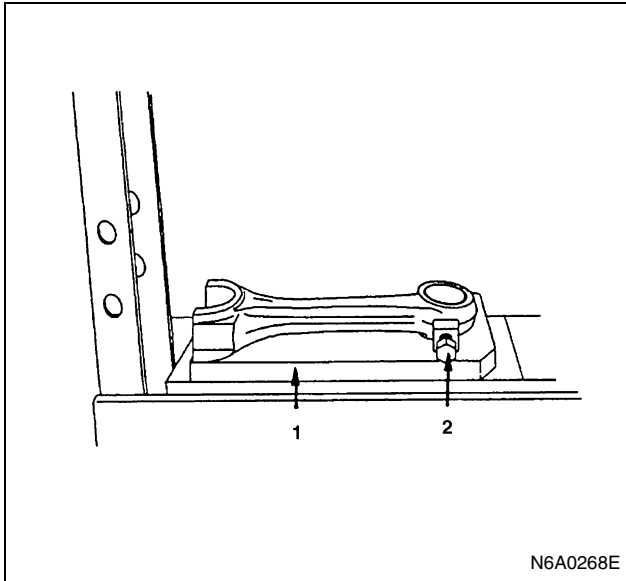
3. Set the connecting rod bushing replacer base (6) to the bench press.
4. Set the connecting rod to the connecting rod bushing replacer base.
5. Tighten the bolt (7).



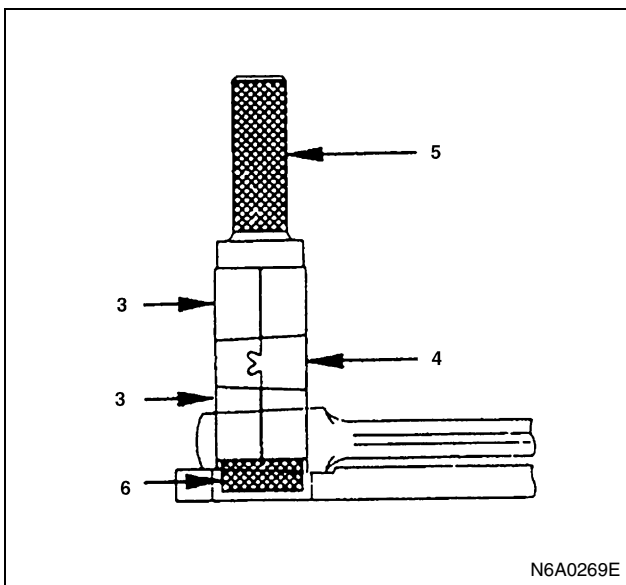
6. Use the bench press to force the bushing from the connecting rod.

Connecting Rod Bushing Installation

1. Set the connecting rod bushing replacer base (1) to the bench press.
Connecting Rod Bushing Replacer: 5-8840-2340-0
2. Set the connecting rod to the connecting rod replacer base.
The connecting rod must be perfectly horizontal.
3. Tighten the bolt (2) to hold the connecting rod small end in place.

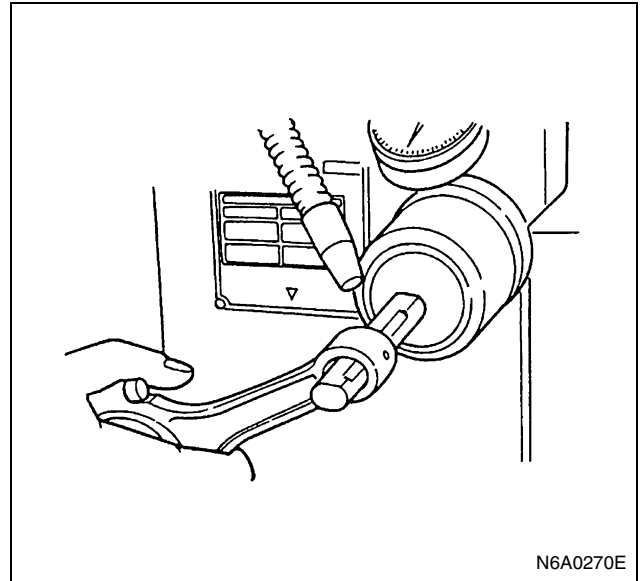


4. Install the two collars (3) and the new bushing (4) to the setting bar (5). Align the bushing clinch line and the collar setting marks. Tighten the nut (6).



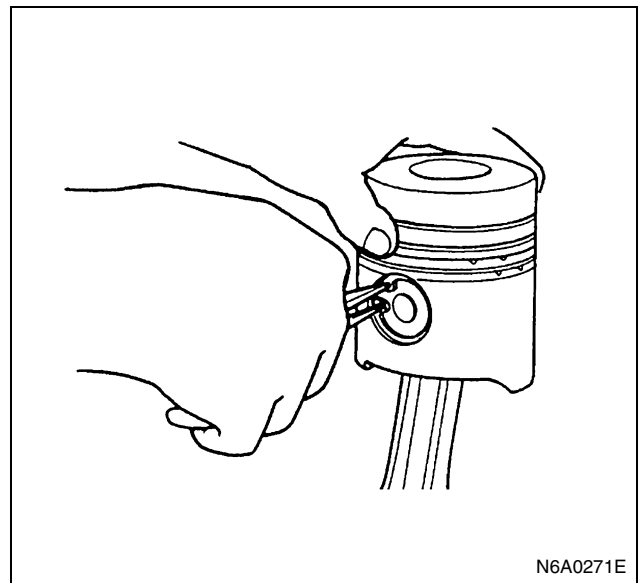
5. Use the bench press to press the new bushing into position inside the connecting rod. Check that the bushing oil holes and the connecting rod oil holes are aligned.
6. Use a pinhole grinder to finish the new bushing.

Connecting Rod Small End Bushing Inside Diameter		mm (in)
Except 4HE1-TC	36.012 — 36.022 (1.4178 — 1.4182)	
4HE1-TC	40.012 — 40.022 (1.5753 — 1.5767)	

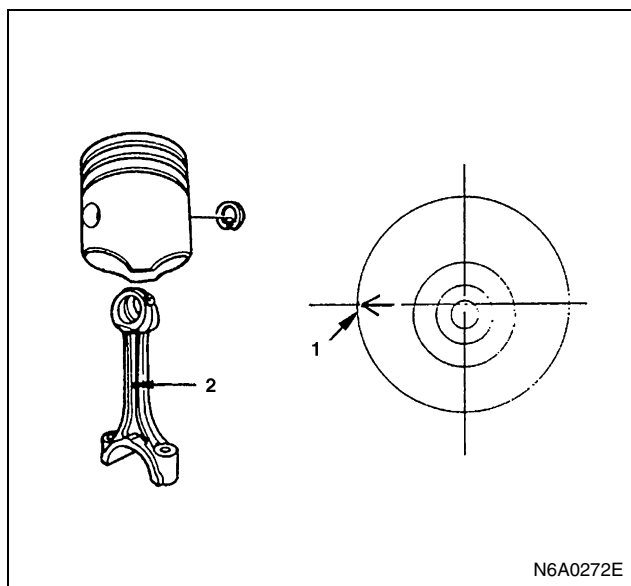


Reassembly

1. Piston
2. Piston Pin Snap Ring
Use a pair of snap ring pliers to install the piston pin snap ring to the piston.



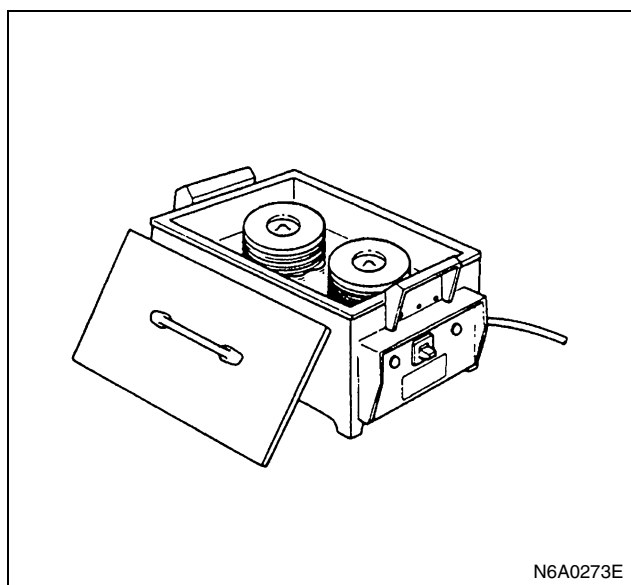
3. Connecting Rod
 - 1) Clamp the connecting rod in a vise. Take care not to damage the connecting rod.
 - 2) Install the connecting rod so that the piston head front mark (1) and the connecting rod forging mark (projecting) (2) are set in the same direction.



4. Piston Pin

If could not be installed piston pin, it is recommended to remove it by following procedure.

- 1) Use a piston heater to heat the piston to 80 — 100°C (176 — 212°F).



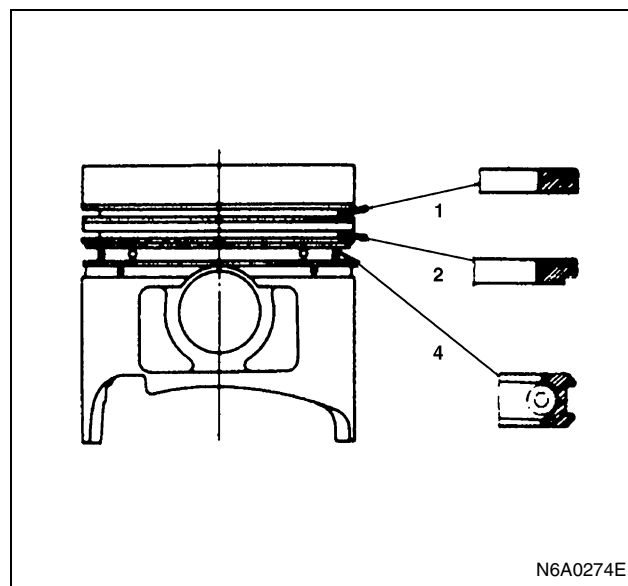
- 2) Apply a coat of the engine oil to the piston pin.
- 3) Use your fingers to force the piston pin into the piston until it makes contact with the snap ring.
- 4) Check to see if the connecting rod moves smoothly on the piston pin.

5. Snap Ring

6. Piston Ring

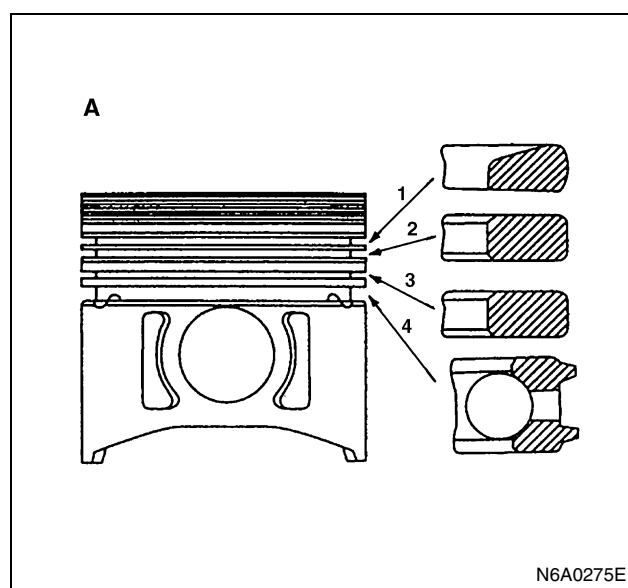
- 1) Use a piston ring replacer to install the three piston rings.

Install the piston rings in the order shown in the illustration.



Legend

1. 1st compression ring
2. 2nd compression ring
4. Oil ring



Legend

- A. For 4HE1-TC
1. 1st compression ring
2. 2nd compression ring
3. 3rd compression ring (For 4HE1-TC)
4. Oil ring

Notice:

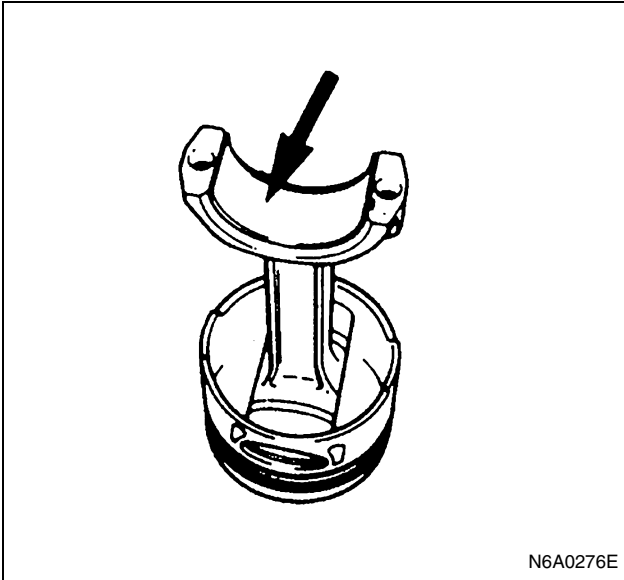
Insert the expander coil into the oil ring groove so that there is no gap on either side of the expander coil before installing the oil ring.

Install the compression rings with the stamped side facing up.

- 2) Apply engine oil to the piston ring surfaces.

- 3) Check to see if the piston rings rotate smoothly in the piston ring grooves.

7. Connecting Rod Bearing
Carefully wipe any oil or other foreign material from the connecting rod bearing back face and the connecting rod bearing fitting surface.

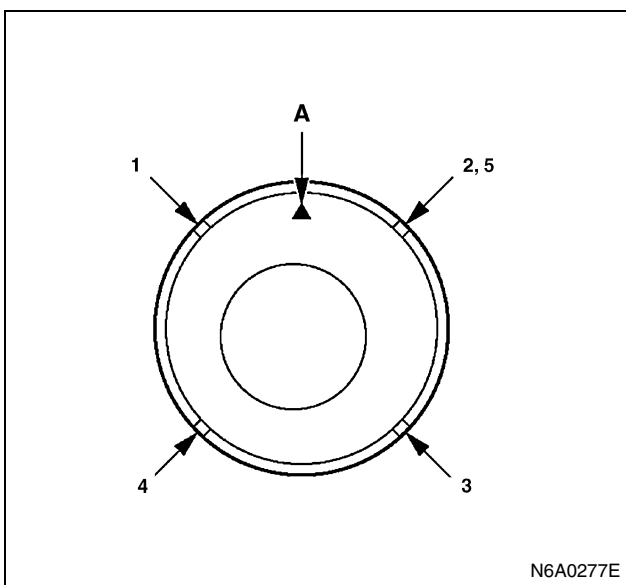


8. Piston and Connecting Rod Assembly

Notice:

When installing new connecting rod and/or connecting rod bearings, refer to the selection table. Above works refer to "CRANKSHAFT" section in this manual.

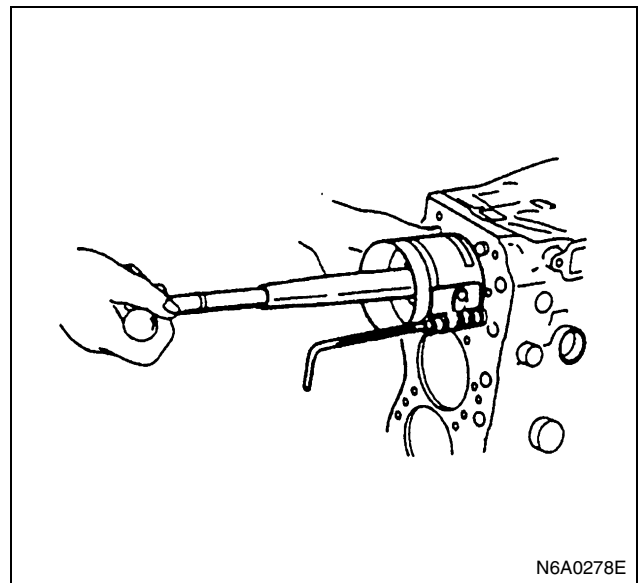
- 1) Apply a coat of the engine oil to the circumference of each piston ring and piston.
- 2) Position the piston ring gaps as shown in the illustration.



Legend

- A. Front mark
- 1. 1st compression ring
- 2. 2nd compression ring
- 3. 3rd compression ring (For 4HE1-TC only)
- 4. Oil ring
- 5. Coil expander

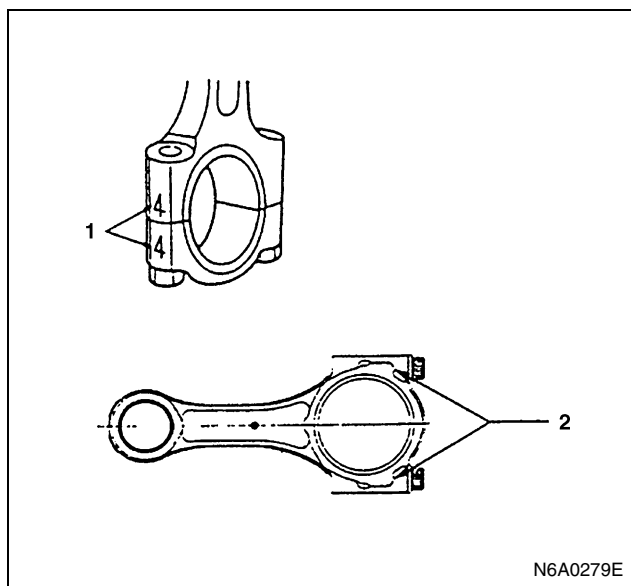
- 3) Apply a coat of molybdenum disulfide grease to the two piston skirts.
This will facilitate smooth break-in when the engine is first started after reassembly.
- 4) Apply a coat of the engine oil to the upper bearing surfaces.
- 5) Apply a coat of the engine oil to the cylinder wall.
- 6) Position the piston head front mark so that it is facing the front of the engine.
- 7) Use the piston ring compressor to compress the piston rings.
Piston Ring Compressor: 5-8840-9018-0
- 8) Use a hammer grip to push the piston in until the connecting rod makes contact with the crankpin.
At the same time, rotate the crankshaft until the crankpin is at bottom dead center.



Caution:

Do not bend or damage the oiling jet.

9. Connecting Rod Cap
 - 1) Install the connecting rod bearing caps.
 - 2) Align the bearing cap cylinder number marks (1) and the connecting rod cylinder number marks (1).
 - 3) Apply a coat of molybdenum disulfide grease to the threads and setting faces of each connecting rod cap bolts.



14. Cylinder Head Assembly
Above works refer to "CYLINDER HEAD" section in this manual.

Legend

1. Alignment
2. Boss discriminating the front from the rear

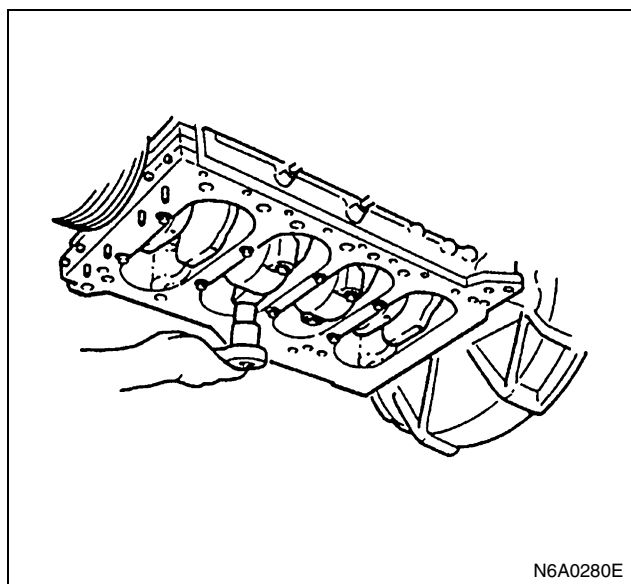
- 4) Tighten the connecting rod caps to the specified torque.

Tighten:

Connecting rod bearing cap bolt to

- 1st step: 39 N·m (4.0 kg·m / 29 lb·ft)
- 2nd step: 60°
- 3rd step: 30°

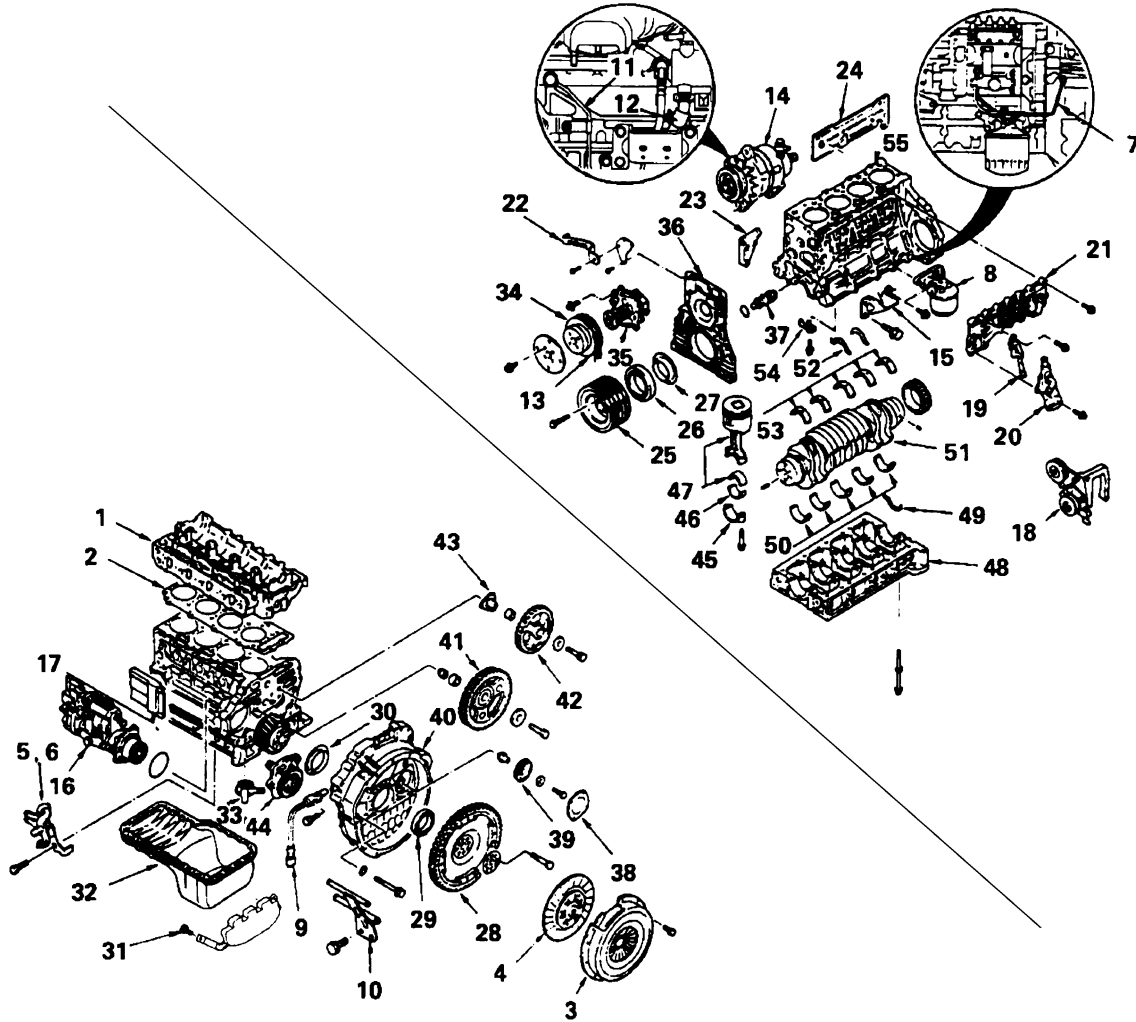
Angle gauge: 5-8840-0266-0



10. Oil Pump Strainer
 11. Oil Pan
 12. Spacer Rubber
 13. Cylinder Head Gasket
- Above works refer to "CYLINDER BLOCK" section in this manual.

CYLINDER BLOCK

Component



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Legend

- | | |
|-----------------------------------|---|
| 1. Cylinder head assembly | 29. Crankshaft rear oil seal |
| 2. Cylinder head gasket | 30. Crankshaft rear slinger |
| 3. Clutch pressure plate assembly | 31. Spacer rubber |
| 4. Driven plate | 32. Oil pan |
| 5. Engine control wire | 33. Oil pump strainer |
| 6. Engine control lever assembly | 34. Water pump pulley |
| 7. Oil pipe | 35. Water pump |
| 8. Oil filter assembly | 36. Front retainer |
| 9. Tachometer sensor | 37. Oil thermo valve |
| 10. Fuel pipe bracket | 38. Power steering pump idle gear cover |
| 11. Vacuum pump oil pipe | 39. Power steering pump idle gear |
| 12. Vacuum pump rubber hose | 40. Flywheel housing |
| 13. Fan belt | 41. Idle gear A |
| 14. Generator | 42. Idle gear B |
| 15. Engine foot | 43. Idle gear B shaft |
| 16. Injection pump assembly | 44. Oil pump assembly |
| 17. Injection pump rubber spacer | 45. Connecting rod cap |
| 18. Idle pulley bracket | 46. Connecting rod lower bearing |
| 19. Heater pipe | 47. Piston and connecting |
| 20. Water suction pipe | 48. Crankcase |
| 21. Oil cooler assembly | 49. Thrust bearing lower |
| 22. Fan belt adjust plate | 50. Crankshaft bearing lower |
| 23. Generator bracket | 51. Crankshaft assembly |
| 24. Cover | 52. Thrust bearing upper |
| 25. Crankshaft pulley | 53. Crankshaft bearing upper |
| 26. Crankshaft front oil seal | 54. Piston oil jet |
| 27. Crankshaft front slinger | 55. Cylinder block |
| 28. Flywheel assembly | |

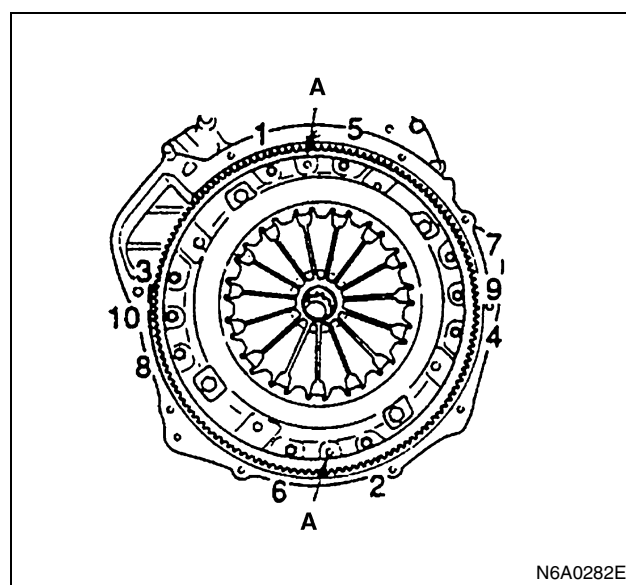
Disassembly

1. Cylinder Head Assembly
Above works refer to "CYLINDER HEAD" section in this manual.
2. Cylinder Head Gasket

Caution:

Do not reuse the cylinder head gasket.

3. Clutch Pressure Plate Assembly
 - 1) Insert the clutch pilot a slinger to the clutch assembly.
Clutch Pilot Aligner: 5-8840-2240-0
 - 2) Loosen the pressure plate bolts in numerical order a little at a time as shown in the illustration.

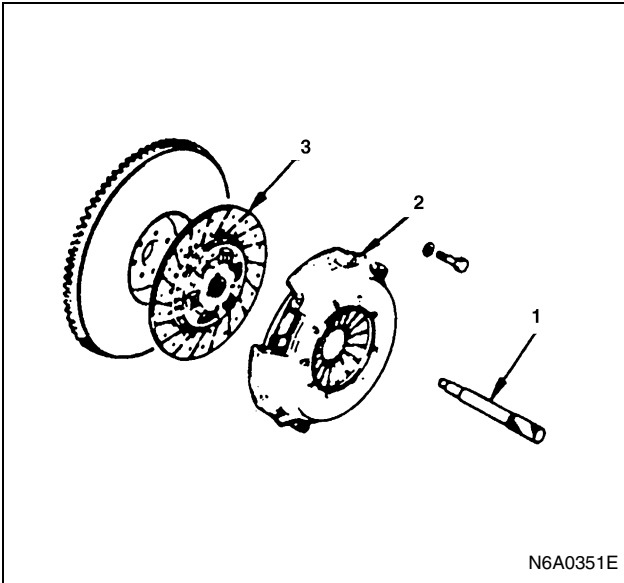


N6A0282E

Legend

- A. Knock pin

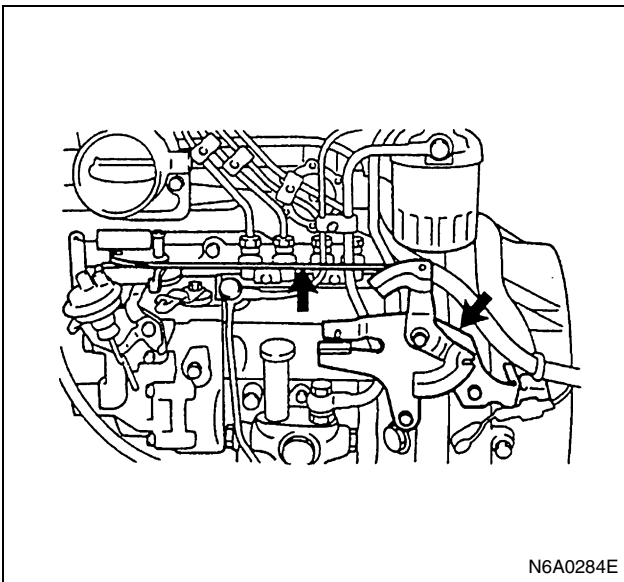
- 3) Remove the pressure plate assembly.
4. Driven Plate
Remove the driven plate with the clutch pilot aligner.



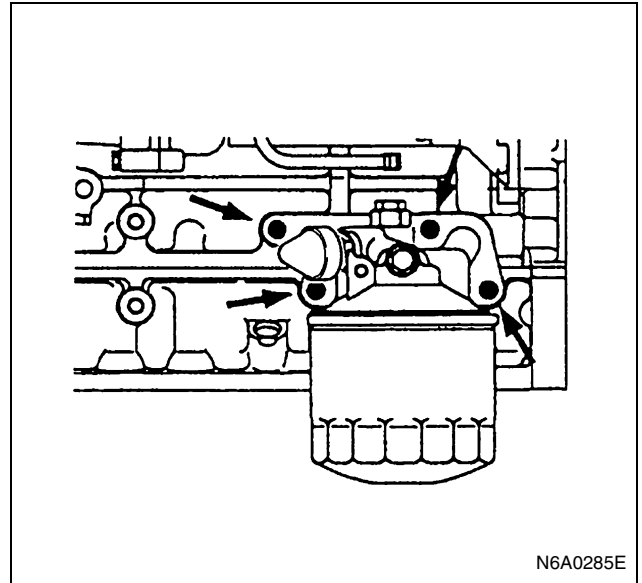
Legend

- 1. Clutch pilot aligner
- 2. Clutch pressure plate assembly
- 3. Driven plate

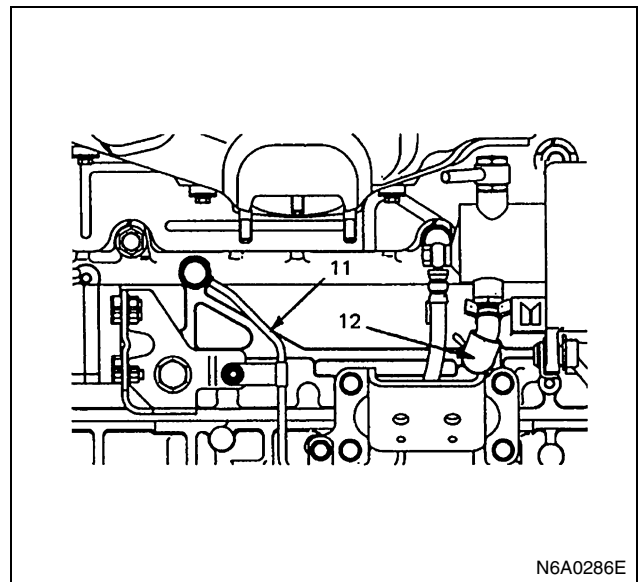
- 5. Engine Control Wire
- 6. Engine Control Lever Assembly
- 7. Oil Pipe



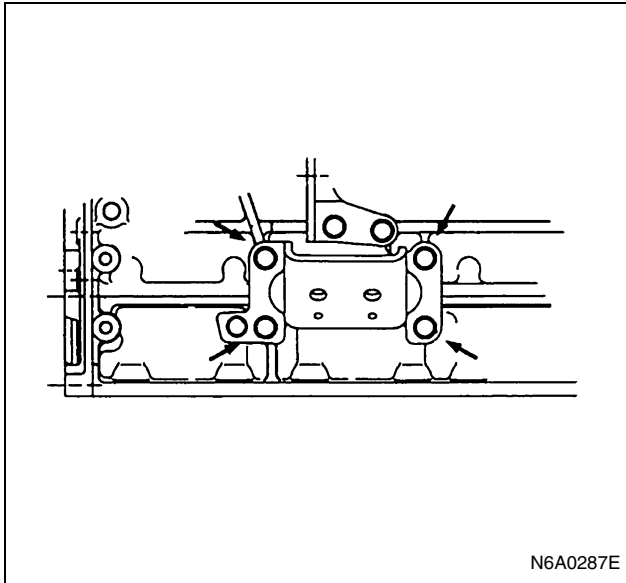
- 8. Oil Filter Assembly
- 9. Tachometer Sensor
- 10. Fuel Pipe Bracket



- 11. Vacuum Pump Oil Pipe (11)
- 12. Vacuum Pump Rubber Hose (12)

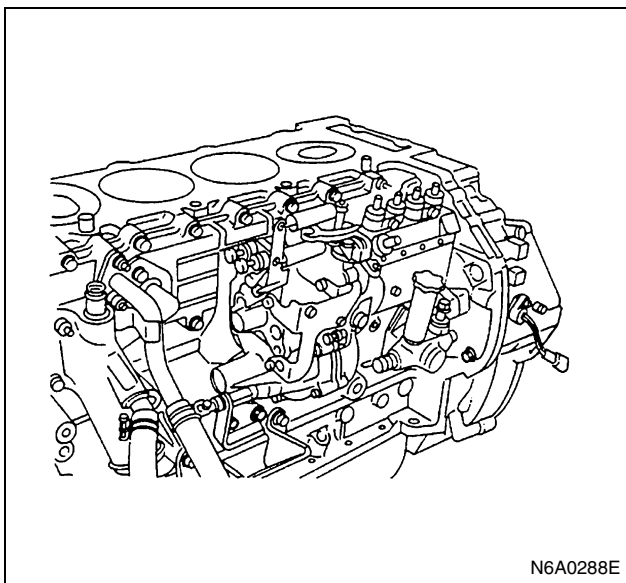


- 13. Fan Belt
- 14. Generator
- 15. Engine Foot



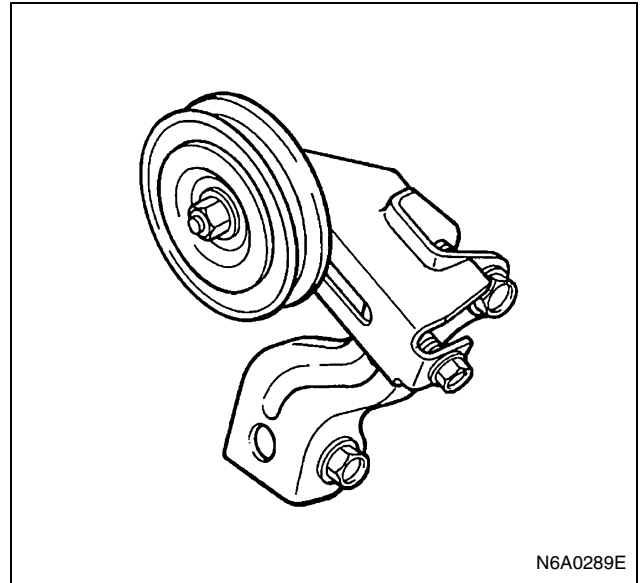
16. Injection Pump Assembly

- 1) Remove the injection pump bracket bolts and the injection pump rear bracket bolts.
- 2) Then remove the injection pump assembly.



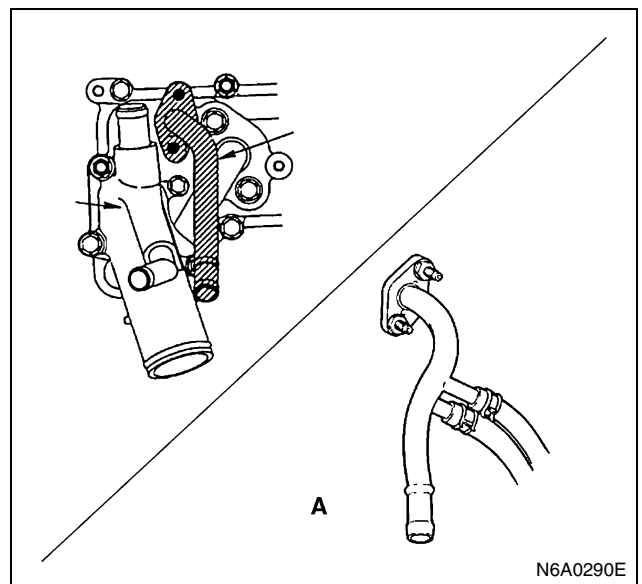
17. Injection Pump Rubber Spacer

18. Idle Pulley Bracket (If equipped with A/C)



19. Heater Pipe

20. Water Suction Pipe

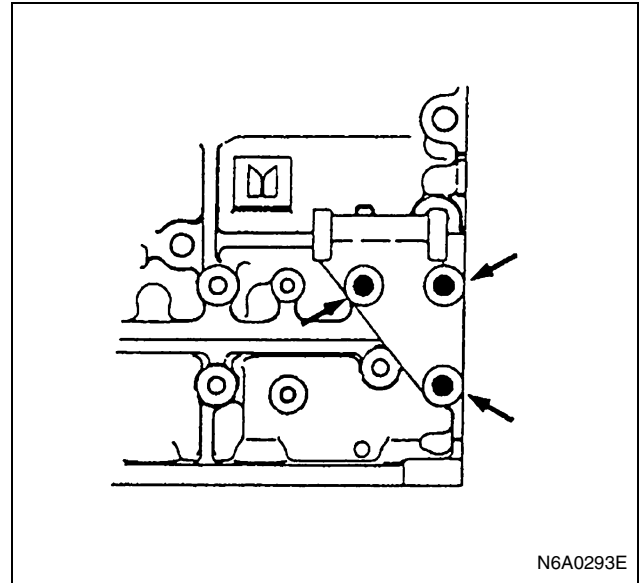
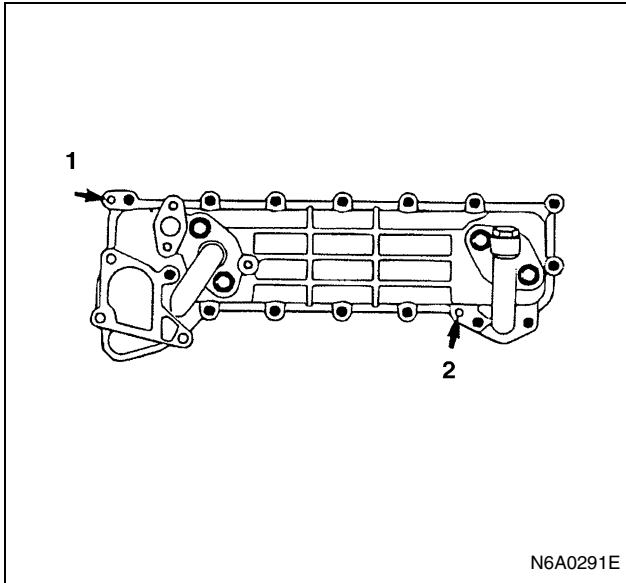


Legend

A. 4HF1-2

21. Oil Cooler Assembly

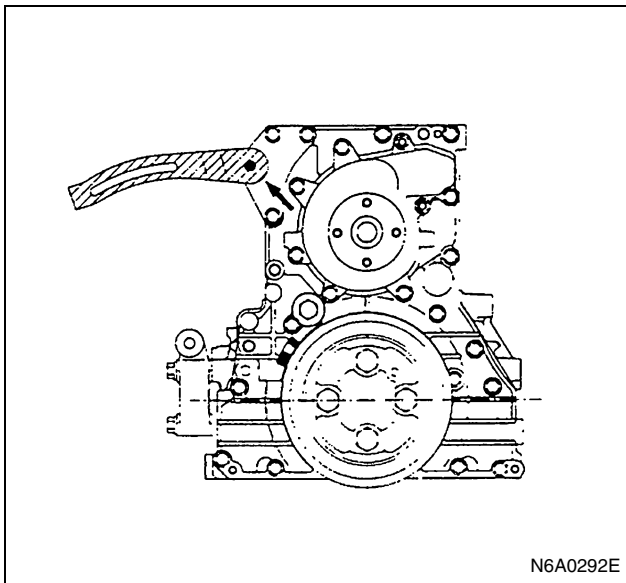
- 1) Remove the oil cooler bolts.
- 2) Install a oil cooler fixing bolt to the oil cooler replacer hole as shown in the illustration, and tighten the bolt alternately a little at a time.



Legend

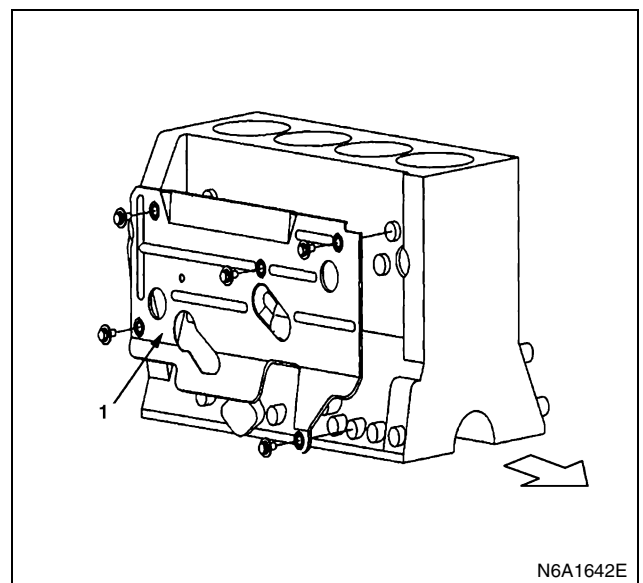
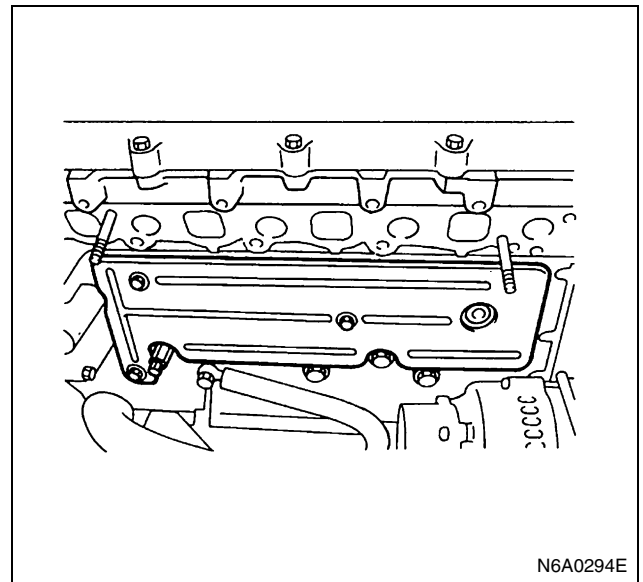
- 1. 4HE1-TC
- 2. 4HF1, 4HG1-T

22. Fan Belt Adjust Plate



23. Generator Bracket

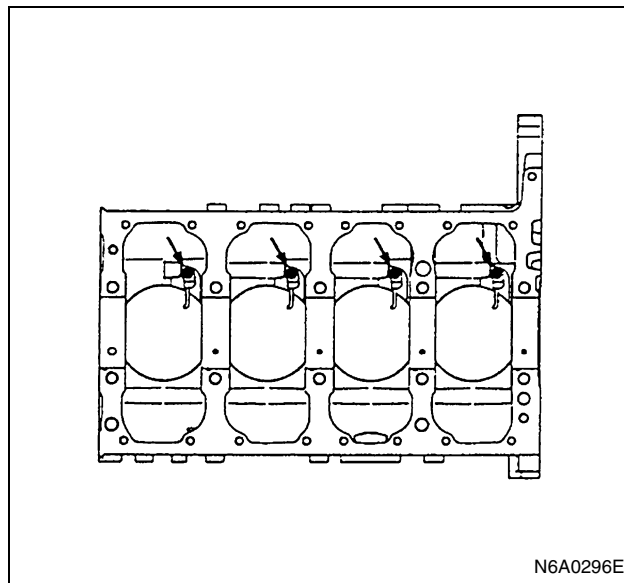
24. Cover



Legend

1. Cover

25. Crankshaft Damper Pulley
26. Crankshaft Front Oil Seal
27. Crankshaft Front Slinger
28. Flywheel Assembly
29. Crankshaft Rear Oil Seal
30. Crankshaft Rear Slinger
31. Space Rubber (NKR model only)
32. Oil Pan
33. Oil Pump Strainer
34. Water Pump Pulley
35. Water Pump
36. Front Retainer
37. Oil Thermo Valve
38. Power Steering Pump Idle Gear Cover
39. Power Steering Pump Idle Gear
40. Flywheel Housing
41. Idle Gear A
42. Idle Gear B
43. Idle Gear B Shaft
44. Oil Pump Assembly
45. Connecting Rod Cap
46. Connecting Rod Lower Bearing
47. Piston and Connecting Rod Assembly
48. Crankcase
49. Thrust Bearing Lower
50. Crankshaft Bearing Lower
51. Crankshaft Assembly
52. Thrust Bearing Upper
53. Crankshaft Bearing Upper
Above works refer to "CRANKSHAFT" section in this manual.
54. Piston Oiling Jet
Loosen the check valves to remove both the check valves and the oiling jets.
Take care not to bend or damage the oiling jets.



55. Cylinder Block

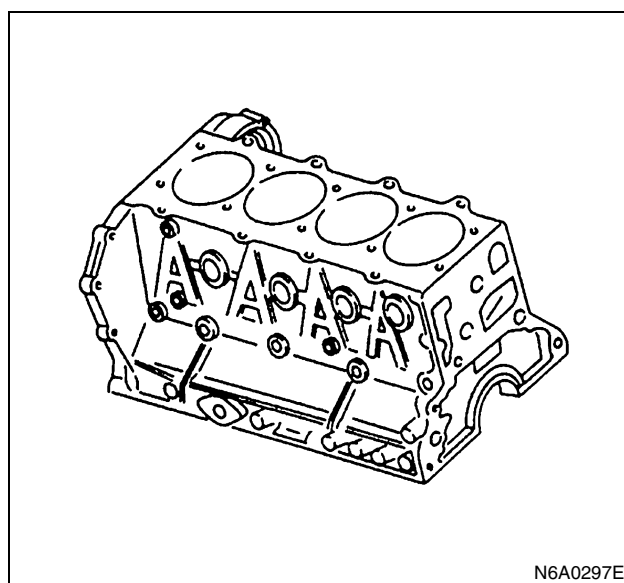
Inspection and Repair

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

1. Remove the gasket and any other material adhering to the upper surface of the cylinder block.
Be very careful not to allow any material to accidentally drop into the cylinder block.
Be very careful not to scratch the cylinder block.
2. Carefully remove the oil pump, rear oil seal, and oil pan installation surface seal.
3. Wipe the cylinder block clean.

Cylinder Body Upper Face Warpage

1. Remove the cylinder body dowel.
2. Remove the cylinder liner.
Refer to "Cylinder Liner Replacement".



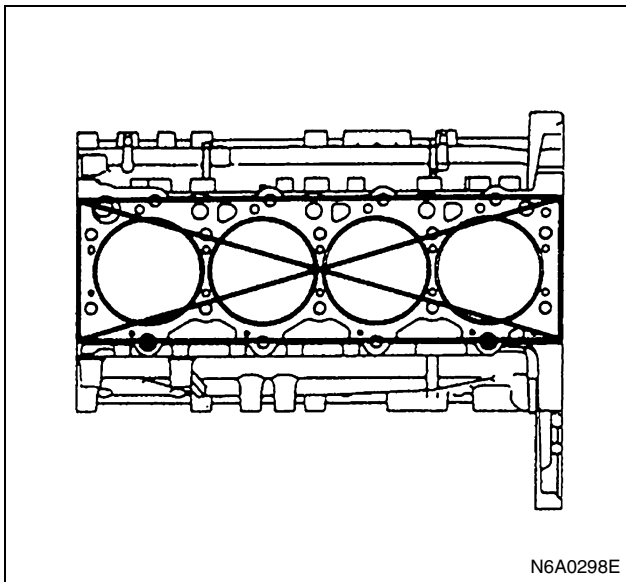
3. Use a straight edge and a feeler gauge to measure the four sides and the two diagonals of the cylinder body upper face.
4. If the measured values exceed the specified limit, the cylinder body must be replaced.

Caution:

Do not regrind the cylinder body upper face.

Cylinder Body Upper Face Warp		mm (in)
Standard	Limit	
0.05 (0.002) or less	0.20(0.008)	

Cylinder Body Height (H) (Reference)	mm (in)
Standard	
279.965 — 280.035 (11.022 — 11.025)	



5. Reinstall the cylinder liner.
Refer to the "Cylinder Body Bore Measurement".
6. Reinstall the cylinder body dowel.

Cylinder Liner Bore Measurement

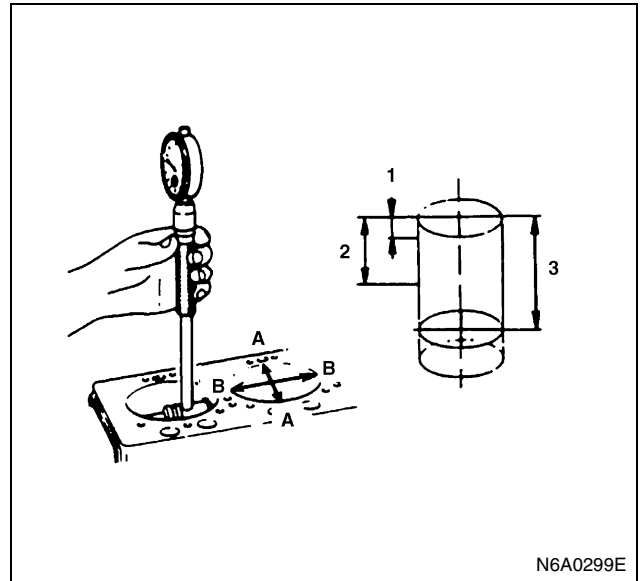
Use a cylinder indicator to measure the cylinder bore at measuring points (1), (2) and (3) in the A — A and B — B directions of the crankshaft.

Measuring points:

1. 20 mm (0.79 in)
2. 90 mm (3.54 in)
3. 160 mm (6.30 in)

If the measured value exceeds the specified limit, the cylinder liner must be replaced.

Cylinder Liner Bore		mm (in)
	Standard	Limit
4HF1 4HF1-2	112.021 — 112.050 (4.4103 — 4.4114)	112.20 (4.417)
4HG1 4HG1-T	115.021 — 115.050 (4.5284 — 4.5295)	115.20 (4.535)
4HE1-TC	110.041 — 110.080 (4.3323 — 4.3338)	110.23 (4.340)

**Notice:**

The inside of the dry type cylinder liner is made of thin cast iron. It cannot be rebored or honed.

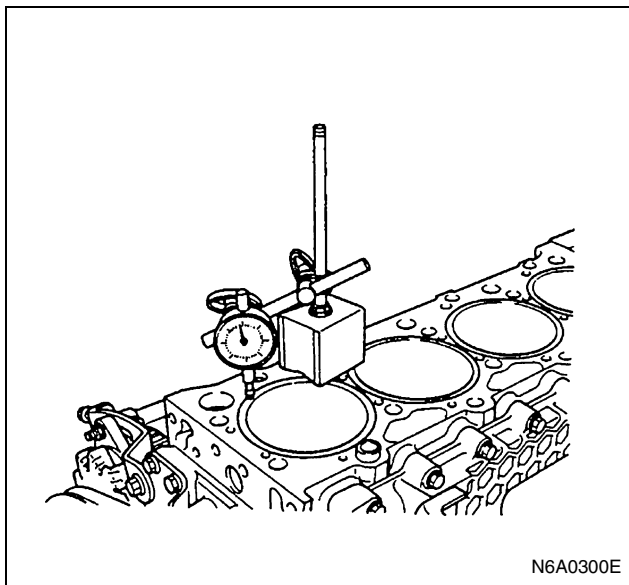
If the inside of the cylinder liner is scored or scorched, the cylinder liner must be replaced.

Cylinder Liner Projection Inspection

Use a dial gauge to measure the projection of each cylinder.

Cylinder Liner Projection	mm (in)
Standard	
0.09 — 0.14 (0.0035 — 0.0055)	

The difference in the cylinder liner projection height between any two adjacent cylinders must not exceed 0.03 mm (0.0012 in).



Cylinder Liner Replacement

Cylinder Liner Removal

If could not be removed cylinder liner, it is recommended to remove it by following procedure.

1. Set the cylinder liner remover (1) to the cylinder liner (3).
2. Check to see if the remover shaft ankle (2) is firmly gripping the cylinder liner bottom edge.
3. Slowly turn the remover shaft handle (4) clockwise to pull the cylinder liner free.

Cylinder Liner Remover:

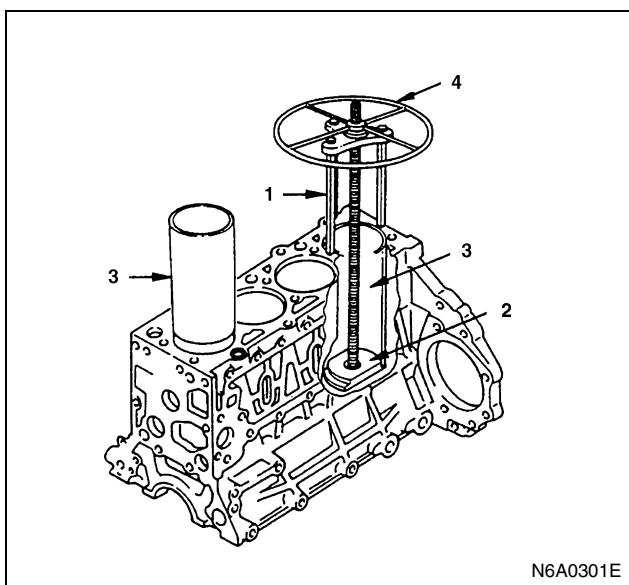
9-8523-1169-0

Cylinder Liner Remover Ankle:

5-8840-2220-0

Ankle:

5-8840-2397-0 (4HG1)



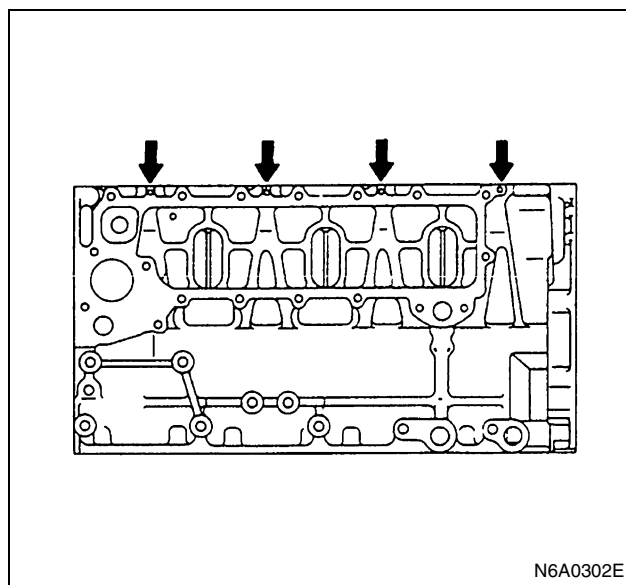
Cylinder Liner Grade Selection and Standard Fitting Interference

Accurately measured fitting interference and proper cylinder liner grade selection are extremely important.

If the cylinder liner fitting interference is too small, engine cooling efficiency will be adversely affected.

If the cylinder liner fitting interference is too large, it will be difficult to insert the cylinder liner into the cylinder body.

A mark was stamped on the left side of the cylinder block during production to indicate the correct liner. The liner grade (i.e. 1, 2, 3) is indicated in metal stamp.



Cylinder Liner Grade

- 4HF1 / 4HF1-2

Line Grade	Cylinder Bore Diameter mm (in.)	Service Grade	Liner Outside Diameter mm (in.)
1	115.001 — 115.010 (4.5276 — 4.5279)	1X	114.991 — 115.000 (4.5272 — 4.5276)
2	115.011 — 115.020 (4.5280 — 4.5283)	3X	115.001 — 115.010 (4.5276 — 4.5279)
3	115.021 — 115.030 (4.5284 — 4.5287)		

Caution:

Take care not to damage the cylinder body upper face during the cylinder liner removal procedure.

• 4HG1 / 4HG1-T

Line Grade	Cylinder Bore Diameter mm (in.)	Service Grade	Liner Outside Diameter mm (in.)
1	118.001 — 118.010 (4.6457 — 4.6461)	1X	117.991 — 118.000 (4.6453 — 4.6457)
2	118.011 — 118.020 (4.6461 — 4.6464)	3X	118.001 — 118.010 (4.6457 — 4.6461)
3	118.021 — 118.030 (4.6465 — 4.6468)		

• 4HE1-TC

Line Grade	Cylinder Bore Diameter mm (in.)	Service Grade	Liner Outside Diameter mm (in.)
1	115.001 — 115.010 (4.5276 — 4.5279)	1X	115.021 — 115.030 (4.5284 — 4.5287)
2	115.011 — 115.020 (4.5280 — 4.5283)	3X	115.031 — 115.040 (4.5289 — 4.5291)
3	115.021 — 115.030 (4.5284 — 4.5287)		

The cylinder liner grade is stamped on the outside of the cylinder liner.

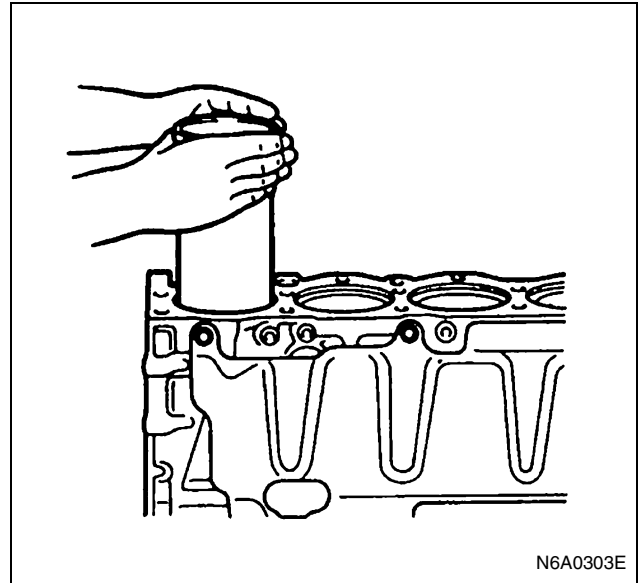
Cylinder Liner Installation (For 4HF1, 4HF1-2, 4HG1 and 4HG1-T Engine)

1. Use new kerosene or diesel oil to thoroughly clean the cylinder liners and bores.
2. Use compressed air to blow dry the cylinder liner and bore surfaces.

Caution:

All foreign material must be carefully removed from the cylinder liner and the cylinder bore before installation.

3. Install the cylinder liner perpendicularly to the cylinder bore. Do not give any excessive force such as knocking while inserting cylinder liner into the cylinder bore.


Cylinder Liner Installation (For 4HE1-TC Engine)

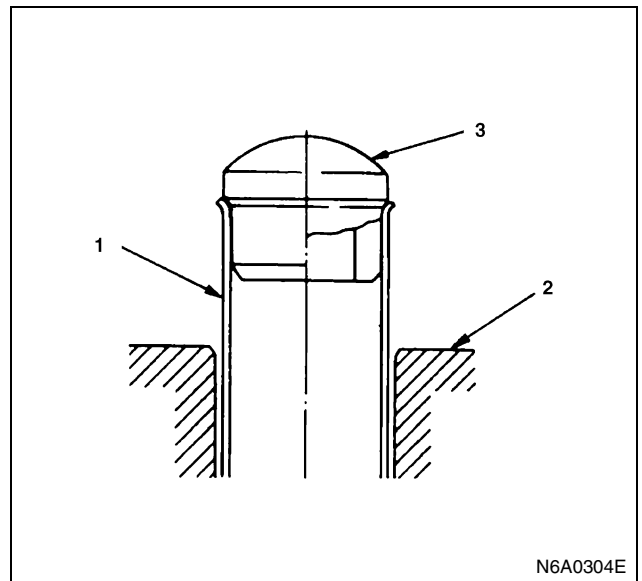
1. Cylinder Liner Installation Using The Special Tool
 - Use new kerosene or diesel oil to thoroughly clean the cylinder liners and bores.
 - Use compressed air to blow-dry the cylinder liner and bore surfaces.

Caution:

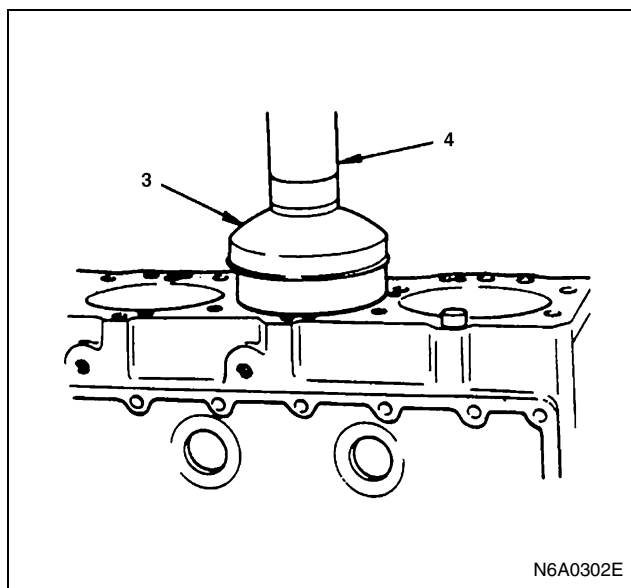
All foreign material must be carefully removed from the cylinder liner and the cylinder bore before installation.

- Insert the cylinder liner (1) into the cylinder body (2) from the top of the cylinder body.
- Set the cylinder liner installer (3) to the top of the cylinder liner.

Cylinder Liner Installer: 5-8840-2337-0



- (3) is directly beneath the bench press shaft center (4).

**Caution:**

Check that the cylinder liner is set perpendicular to the bench press and that there is no wobble.

- Use the bench press to apply a seating force of 4,900 N (500 kg / 1,102.5 lb) to the cylinder liner.
- Apply a force of 24,500 N (2,500 kg / 5,512.5 lb) to fully seat the cylinder liner.
- After installing the cylinder liner, measure the cylinder liner projection.
Refer to "Cylinder Liner Projection Inspection".

2. Cylinder Liner Installation Using Dry Ice

If the cylinder liner is a chrome plated dry type, it is advisable to use dry ice during the installation procedure.

Cooling the cylinder liner with dry ice will cause the cylinder liner to contract, thus making installation easier.

Caution:

It is important that the cylinder liner be inserted to the cylinder body immediately after it has been cooled.

WARNING:

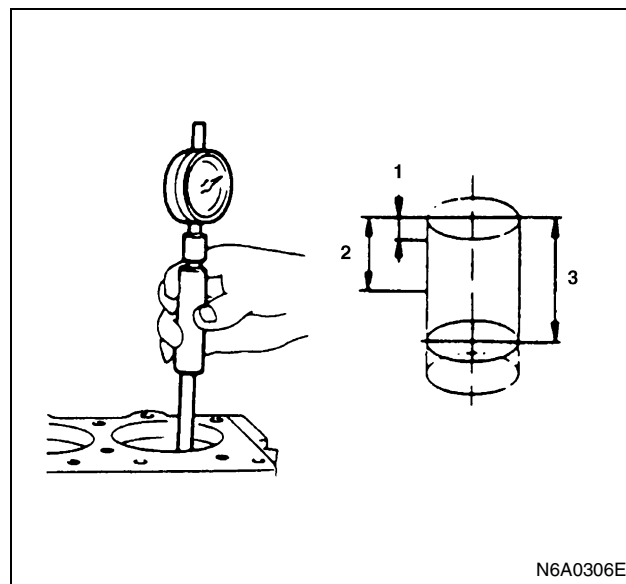
DRY ICE MUST BE USED WITH GREAT CARE. CARELESS HANDLING OF DRY ICE CAN RESULT IN SEVERE FROSTBITE.

Piston Grade Selection

Measure the cylinder liner bore after installing the cylinder liner. Then select the appropriate piston grade for the installed cylinder liner.

1. Measure the cylinder liner bore.
Refer to the "Cylinder Liner Bore Measurement".
Measuring Point (1) 20 mm (0.79 in)
Measuring Point (2) 90 mm (3.54 in)
Measuring Point (3) 160 mm (6.30 in)

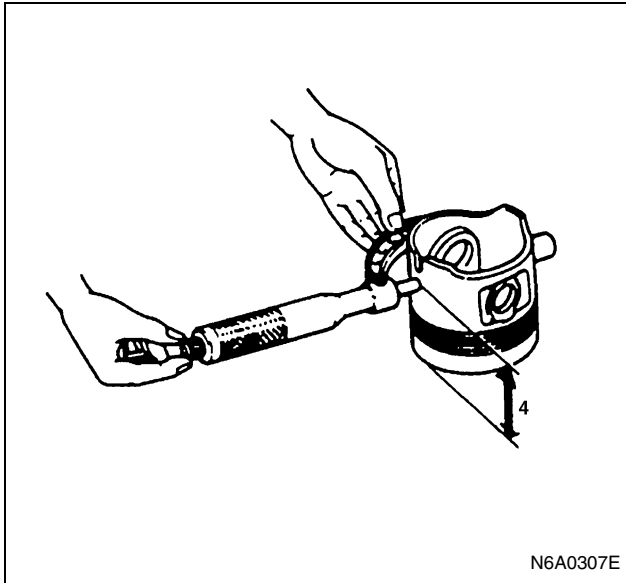
Cylinder Liner Bore		mm (in)
	Standard	Limit
4HF1 4HF1-2	112.021 — 112.050 (4.4103 — 4.4114)	112.20 (4.417)
4HG1 4HG1-T	115.021 — 115.050 (4.5284 — 4.5295)	115.20 (4.535)
4HE1-TC	110.041 — 110.080 (4.3323 — 4.3338)	110.23 (4.340)

**Caution:**

It is most important that the correct piston grade be used. Failure to select the correct piston grade will result in engine failure. Always measure the cylinder bore and select the correct piston grade.

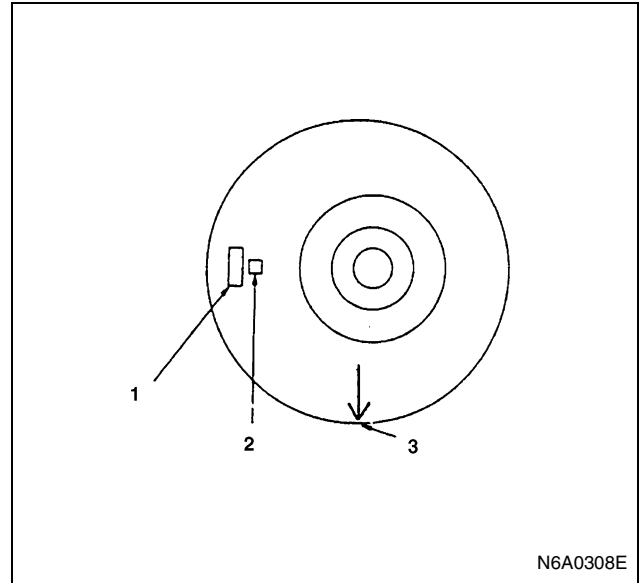
2. Measure the piston outside diameter (Reference).
Piston Measuring Point (4): 82 mm (3.23 in)

Cylinder Liner and Piston Clearance	mm (in)
4HF1 / 4HF1-2: 0.081 — 0.113 (0.0032 — 0.0044)	
4HG1 / 4HG1-T: 0.081 — 0.116 (0.0032 — 0.0046)	
4HE1-TC: 0.091 — 0.131 (0.0036 — 0.0052)	



The piston grade (i.e. A, B, C) is indicated in metal stamp on the piston upper face.

Piston Grade			
Engine Model	Cylinder Liner Bore Diameter mm (in)	Piston Service Grade	Piston Outside Diameter mm (in)
4HF1 4HF1-2	112.041 — 112.060 (4.4111 — 4.4118)	—	111.944 — 111.959 (4.4072 — 4.4078)
4HG1 4HG1-T	115.041 — 115.060 (4.5292 — 4.5299)	—	114.944 — 114.959 (4.5253 — 4.5259)
4HE1- TC	110.066 — 110.075 (4.3333 — 4.3337)	AX	109.944 — 109.959 (4.3285 — 4.3291)
	110.076 — 110.085 (4.3337 — 4.3340)	CX	109.960 — 109.975 (4.3291 — 4.3297)



Legend

1. Part No.
2. Grade
3. Front mark

Caution:

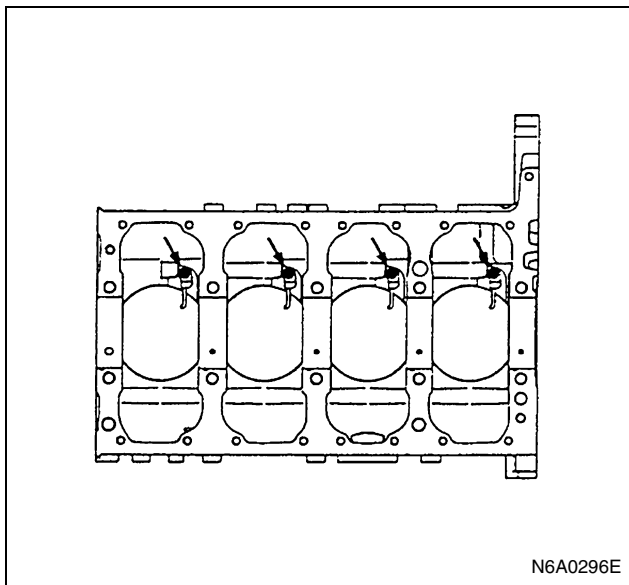
Cylinder liner kit clearances are preset. However, the cylinder liner installation procedure may result in slight decreases in cylinder liner clearances. Always measure the cylinder liner clearance after installation to be sure that it is correct.

Reassembly

1. Cylinder Block
Use compressed air to thoroughly clean the inside and outside surfaces of the cylinder body, the oil holes, and the water jackets.
2. Piston Oiling Jet
 - 1) Install the oiling jets together with the check valves. Take care not to damage the oiling jet nozzles.
 - 2) Tighten the check valves and oiling jets to the specified torque.

Tighten:

Check valve and oiling jet to 21 N·m (2.1 kg·m / 15 lb·ft)

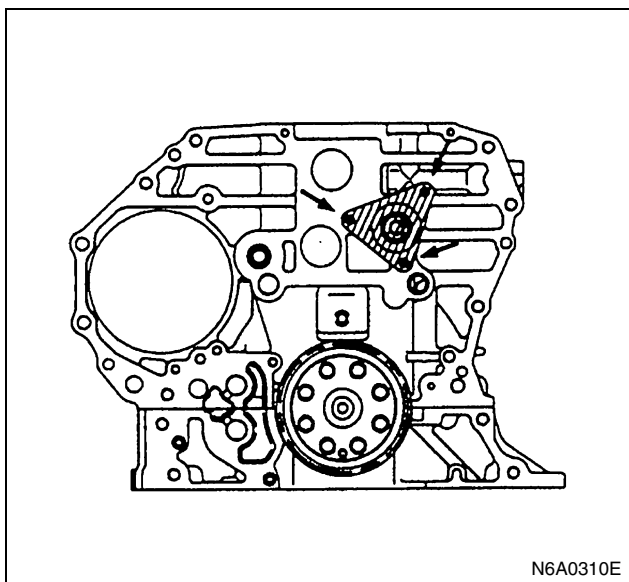


3. Crankshaft Bearing Upper
4. Thrust Bearing Upper
5. Crankshaft Assembly
6. Crankshaft Bearing Lower
7. Thrust Bearing Lower
8. Crankcase
Above works refer to "CRANKSHAFT" section in this manual.
9. Piston and Connecting Rod Assembly
10. Connecting Rod Lower Bearing
11. Connecting Rod Cap
Above works refer to "PISTON AND CONNECTING ROD" section in this manual.
12. Oil Pump Assembly
13. Idle Gear B Shaft

Tighten:

Idle gear B shaft bolt to 31 N·m (3.2 kg·m / 23 lb·ft)

Apply the engine oil to the idle gear shaft after installation.

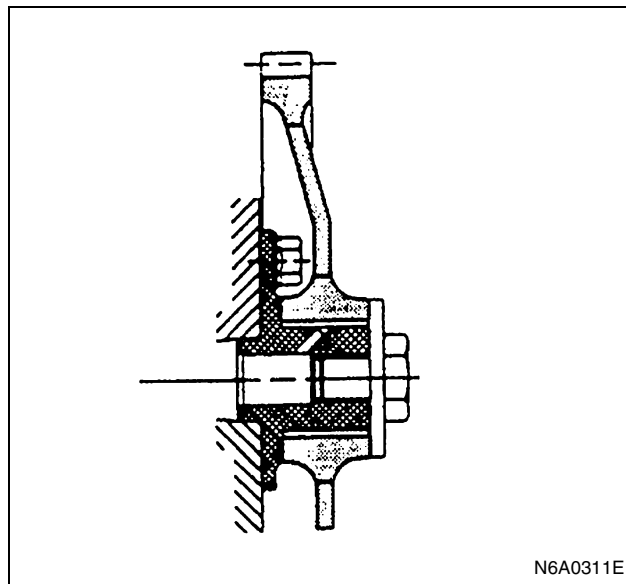


14. Idle Gear B

The face of the idle gear B with longer boss should be positioned toward the rear side shown in the illustration.

Tighten:

Idle gear B bolt to 110 N·m (11.2 kg·m / 81 lb·ft)

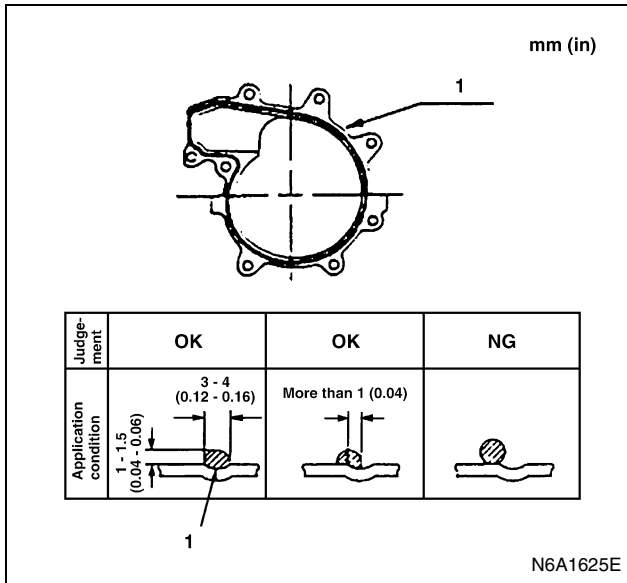


15. Idle Gear A
16. Flywheel Housing
17. Power Steering Pump Idle Gear
18. Power Steering Pump Idle Gear Cover
Above works refer to "OIL PUMP" section in this manual.
19. Oil Thermo Valve
20. Front Retainer
Above works refer to "CRANKSHAFT" section in this manual.
21. Water Pump Assembly
 - 1) Apply 3 — 4 mm (0.12 — 0.16 in) bead of the recommended liquid gasket (Three Bond 1207C) or its equivalent on the water pump fitting surface.
 - 2) Install the water pump to the front retainer.

Tighten:

Water pump bolt to 24 N·m (2.4 kg·m / 17 lb·ft)

- Install the water pump within 7 minutes after application of liquid gasket.
- For the dislocation of liquid gasket, refer to the illustration.

**Legend**

1. Liquid gasket

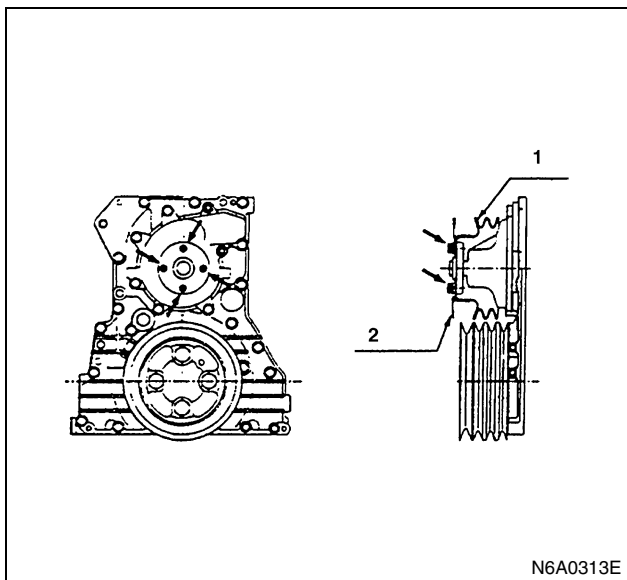
Caution:

The water pump clamping bolt is also used to tighten the front retainer. So, install the water pump before liquid gasket gets dry immediately after installation of the front retainer.

22. Water Pump Pulley

Tighten:

Water pump pulley bolt to 24 N·m (2.4 kg·m / 17 lb·ft)

**Legend**

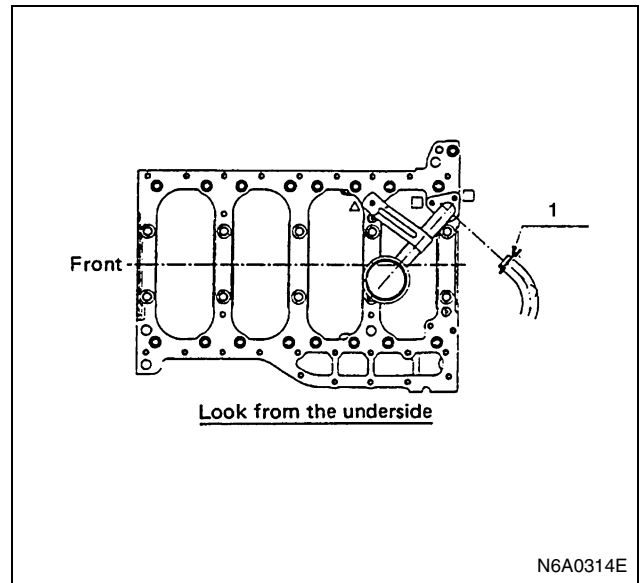
1. Pulley
2. Set plate

23. Oil Pump Strainer

Install the O-ring (1) to the oil pump strainer pipe and install the oil pump strainer to the cylinder body shown in the illustration.

Tighten:

Oil pump strainer bolt to 24 N·m (2.4 kg·m / 17 lb·ft)



24. Oil Pan

Above works refer to "OIL PAN" section in this manual.

25. Spacer Rubber

Tighten:

Spacer rubber bolt to 76 N·m (7.7 kg·m / 56 lb·ft)

26. Crankshaft Rear Slinger

27. Crankshaft Rear Oil Seal

28. Flywheel Assembly

29. Crankshaft Front Slinger

30. Crankshaft Front Oil Seal

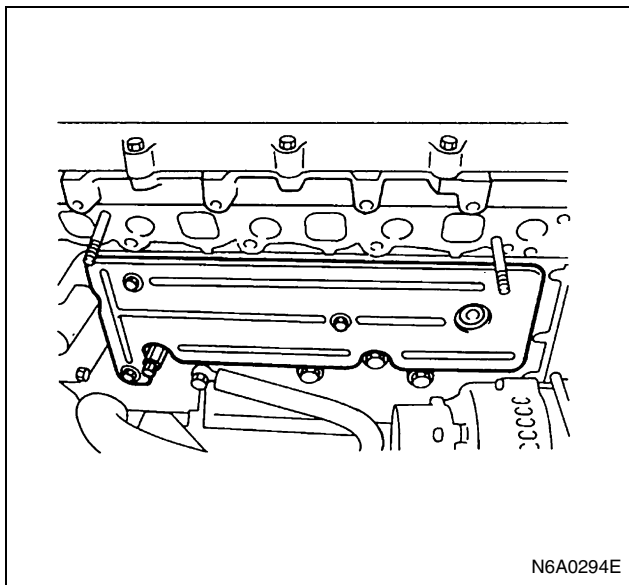
31. Crankshaft Damper Pulley

Above works refer to "CRANKSHAFT" section in this manual.

32. Cover

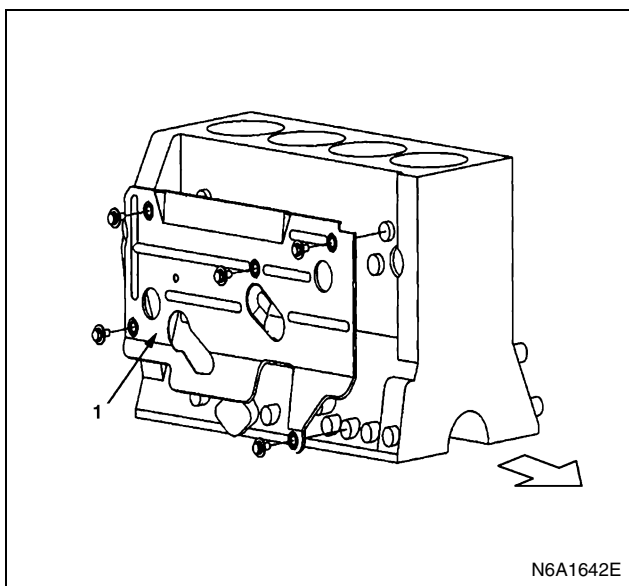
Tighten:

Cover Bolt to 13 N·m (1.3 kg·m / 9 lb·ft)



4HE1-TC

4HE1-TC engines use a larger rubber spacer than other engines.



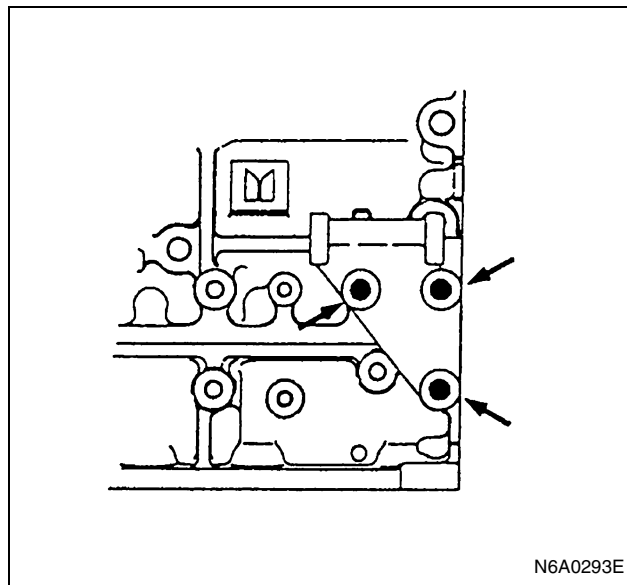
Legend

1. Cover

33. Generator Bracket

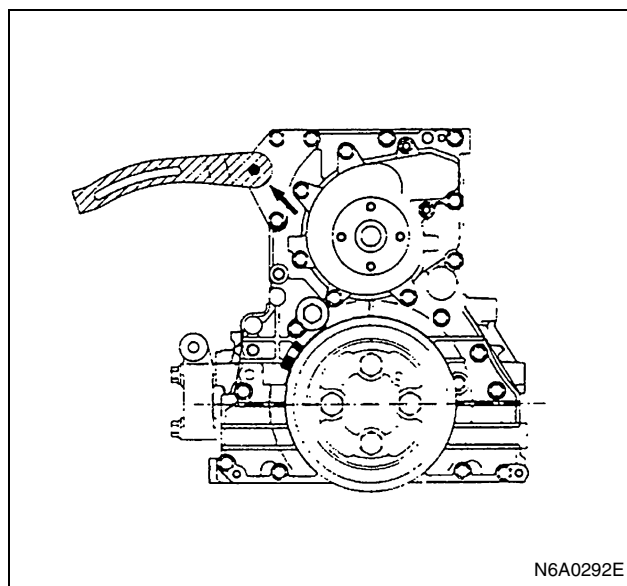
Tighten:

Generator bracket bolt to 48 N·m (4.9 kg·m / 35 lb·ft)



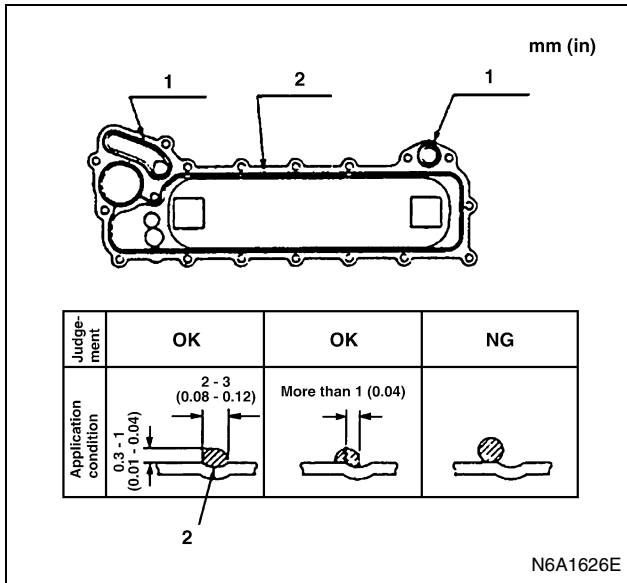
34. Fan Belt Adjust Plate

Install the adjust plate and temporarily tighten the adjust plate bolt.



35. Oil Cooler Assembly

- 1) Apply 2 — 3 mm (0.08 — 0.12 in) bead of the recommended liquid gasket (Three Bond 1207C) or its equivalent on the oil cooler fitting surface.
- 2) Apply a coat of engine oil to the O-rings (2 pieces) and install the O-rings to the oil cooler.

**Legend**

1. O-ring
2. Liquid gasket

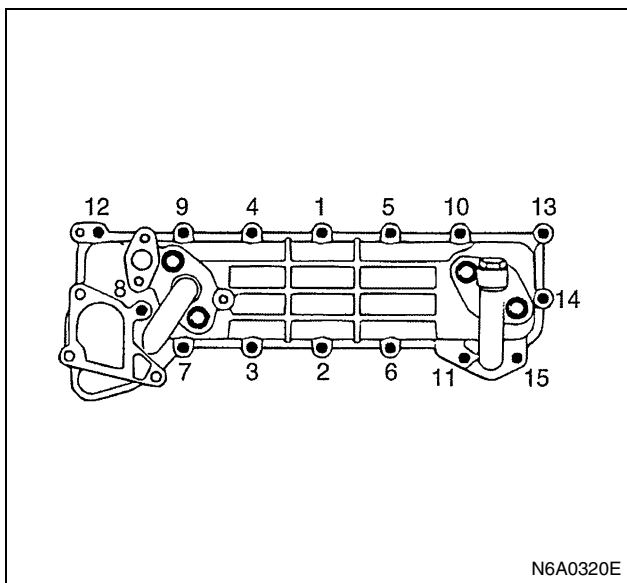
Notice:

Take care that the O-ring is not smeared with liquid gasket.

- Install it within 7 minutes after application of liquid gasket.
 - For the dislocation of liquid gasket, refer to the illustration.
- 3) Tighten the oil cooler bolts and nut to the specified torque a little at a time in the sequence shown in the illustration.

Tighten:

Oil cooler bolt and nut to 24 N·m (2.4 kg·m / 17 lb·ft)

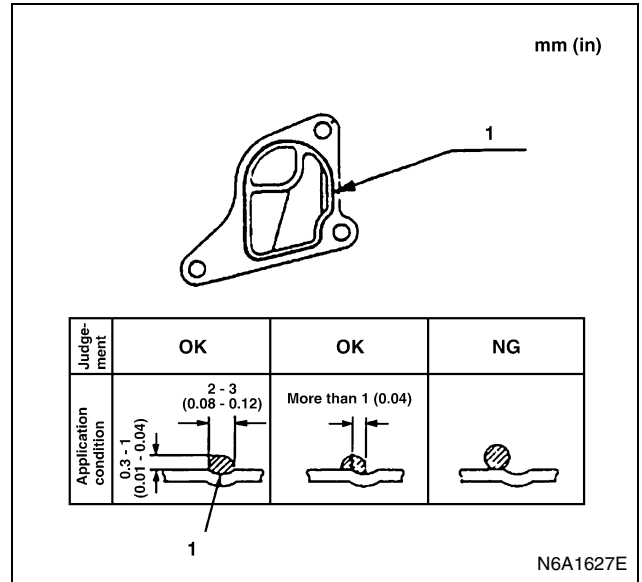
**36. Water Suction Pipe**

- 1) Apply 2 — 3 mm (0.08 — 0.12 in) bead of the recommended liquid gasket (Three Bond

1207C) or its equivalent on the groove of the water suction pipe fitting surface.

- 2) Install the water suction pipe to the oil cooler.

- For the dislocation of liquid gasket, refer to the illustration.

**Legend**

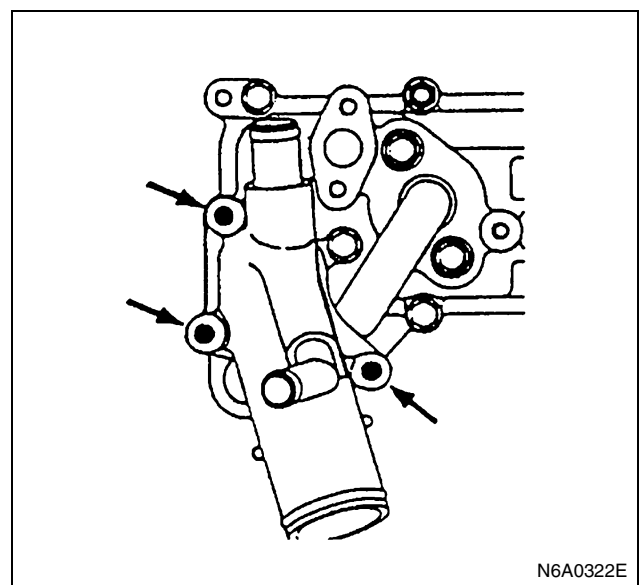
1. Liquid gasket

Tighten:

Water suction pipe bolt and nuts to 24 N·m (2.4 kg·m / 17 lb·ft)

Notice:

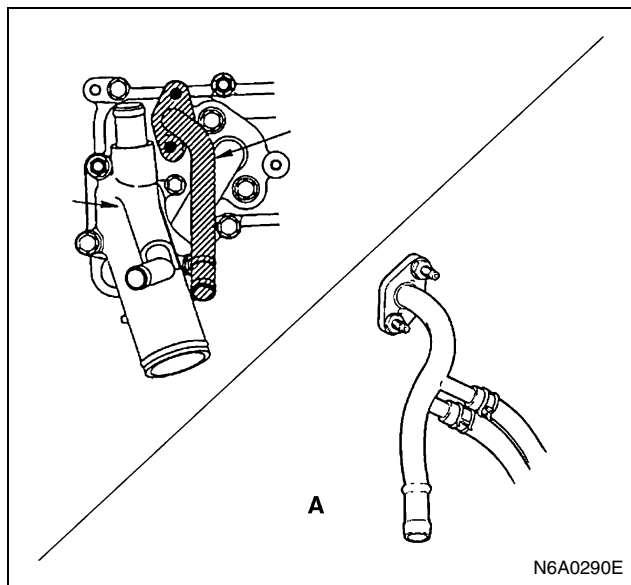
Install the water suction pipe immediately after the installation of the oil cooler.

**37. Heater Pipe**

- 1) Install the O-ring to the heater pipe.
- 2) Install the heater pipe to the oil cooler.

Tighten:

Heater pipe bolt to 24 N·m (2.4 kg·m / 17 lb·ft)

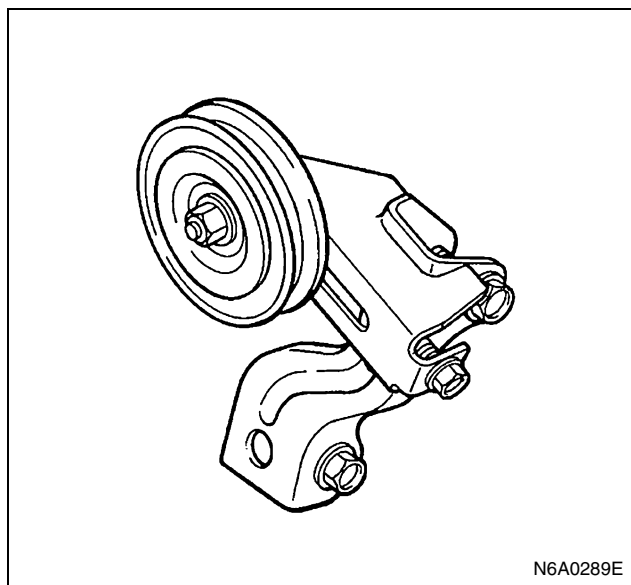

Legend

A. 4HF1-2

38. Idle Pulley Bracket (If equipped with A/C)

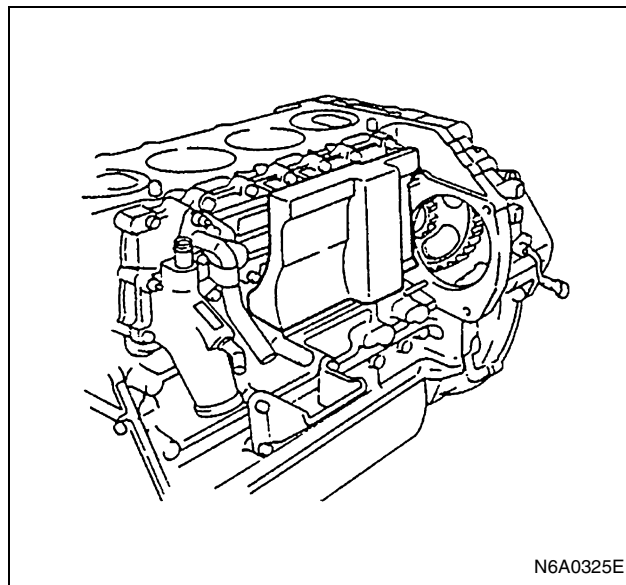
Tighten:

Idle pulley bracket bolt to 48 N·m (4.9 kg·m / 35 lb·ft)



39. Injection Pump Rubber Spacer

Stick the rubber spacer to the location indicated in the illustration with pressure sensitive adhesive double coated tape.

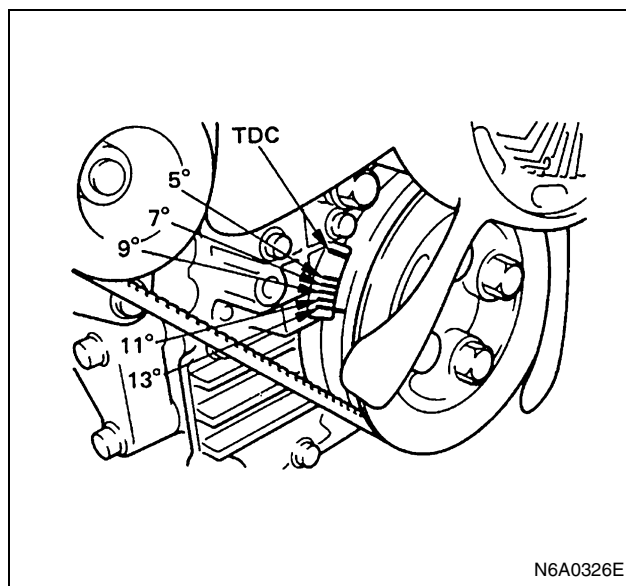


40. Injection Pump Assembly (Except 4HF1-2)

- 1) Turn the crankshaft until the timing mark on the crankshaft damper pulley is aligned with "13°" line.

Notice:

BTDC 13° to be aligned with here is an angle at which the injection pump is installed, and has nothing to do with the injection timing.

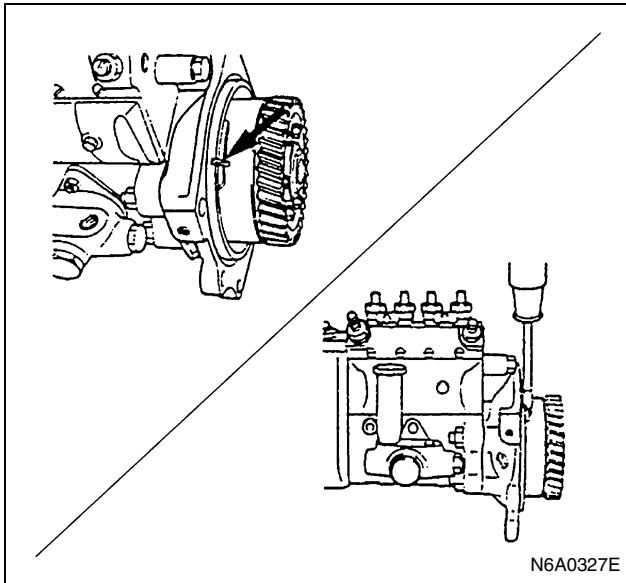


- 2) Remove the inspection hole plug from the cylinder body.
- 3) Install the O-ring to the injection pump bracket.
- 4) Align the injection pump bracket slit with the timer slit.
- 5) Install the injection pump assembly to the cylinder body.

Notice:

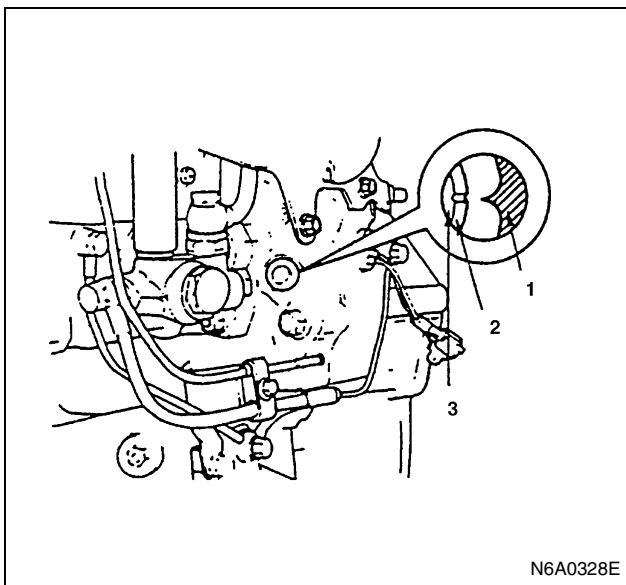
When the injection pump has a poor gear engagement while installing the assembly to the cylinder body, insert a screwdriver into the slit on the timer peripheral with the

pump bracket slit used as a guide, and move it up and down to get it into forcibly.



- 6) After installation of the injection pump, the injection timing can be checked through the timing check hole provided to the injection pump bracket.

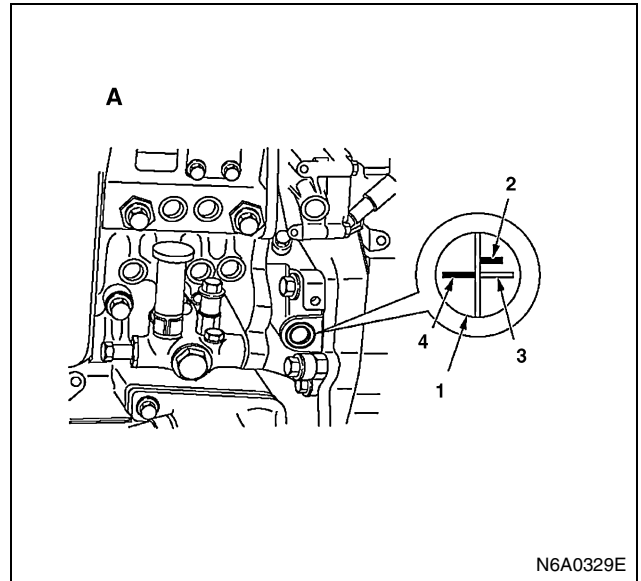
Set the No.1 cylinder to BTDC (Injection timing of each engine model) on the compression stroke. When the pointer of the timing check hole comes in line with the mark on the timer periphery of the injection pump as shown in the illustration, the injection timing is normal. After completion of the injection timing check, tighten the check hole plug to the specified torque.



Legend

1. Pointer
2. Timer outside mark
3. Timing check hole

Injection Timing		deg
4HF1 4HE1-TC (4HE1-XS, XN)	BTDC 8	
4HG1	BTDC 9	
4HG1-T	BTDC 7 (Except Colombia) BTDC 9 (For Colombia)	
4HE1-TC (4HE1-XS)	BTDC 9 (Spec EURO3)	



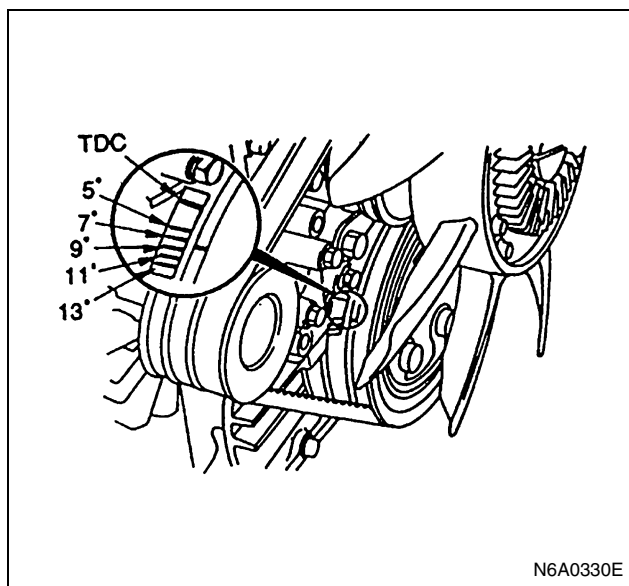
Legend

- A. For 4HF1-TC
1. Timing check hole
 2. 8° Mark
 3. 13° Mark
 4. Pointer

- 7) Turn the crankshaft until the timing mark on the crankshaft damper pulley is aligned with "8°" (98EPA) or "9°" (Spec EURO3) line.

Notice:

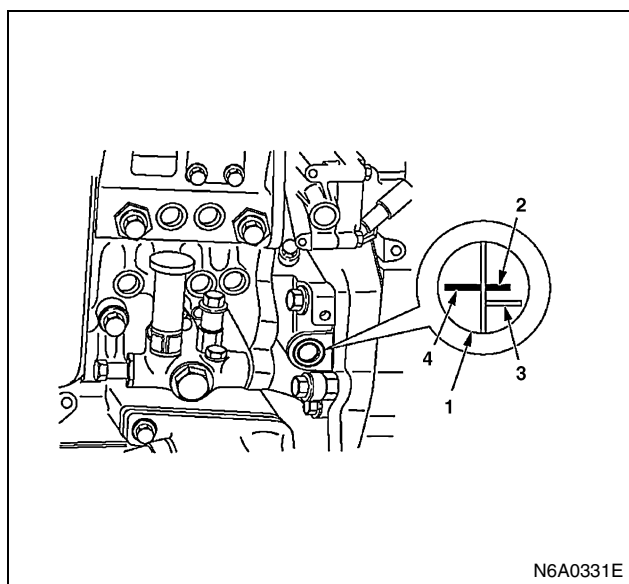
Position in its normal rotating direction. (for 4HE1-TC only)



- 8) Adjust injection pump downward so that the "8°" (98EPA) or "9°" (Spec EURO3) comes to position in the timing check hole. (for 4HE1-TC only)

Notice:

When ever the injection pump is replaced, be sure to adjust the injection timing for the details of the adjustment, refer to the "SECTION 00 SERVICING: INJECTION TIMING INSPECTION AND ADJUSTMENT."



Legend

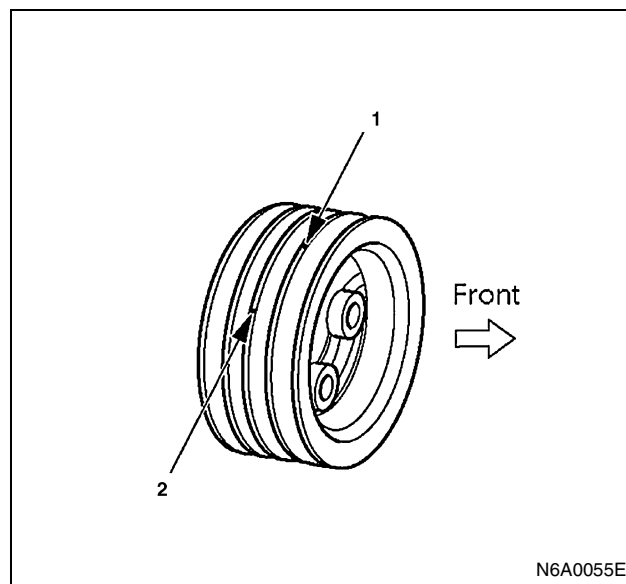
1. Timing check hole
2. 8° Mark
3. 13° Mark
4. Pointer

Notice:

In case the crank pulley has two marks as illustrated, (1) BTDC 49° mark on the second crest and (2) TDC mark on the third crest (as viewed from the front side), be sure

to set at the mark (2). (If there are two different marks on one and same crest, set at the mark which comes second when rotated in the normal direction.)

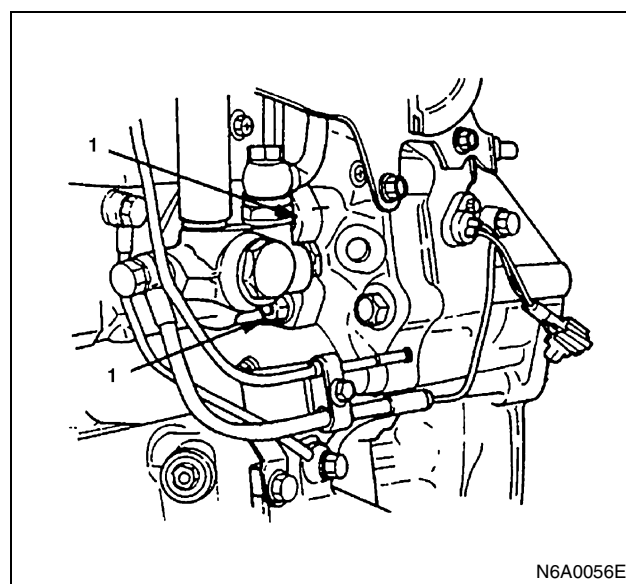
The mark (1) is used when installing the injection pump for 4HF1-2.



- 9) Tighten the injection pump bracket nuts and bolts to the specified torque.

Tighten:

Injection pump bracket nut and bolt (1) to 48 N·m (4.9 kg·m / 35 lb·ft)



- 10) Install the injection pump rear bracket.

Tighten:

Injection pump rear bracket bolt to 48 N·m (4.9 kg·m / 35 lb·ft)

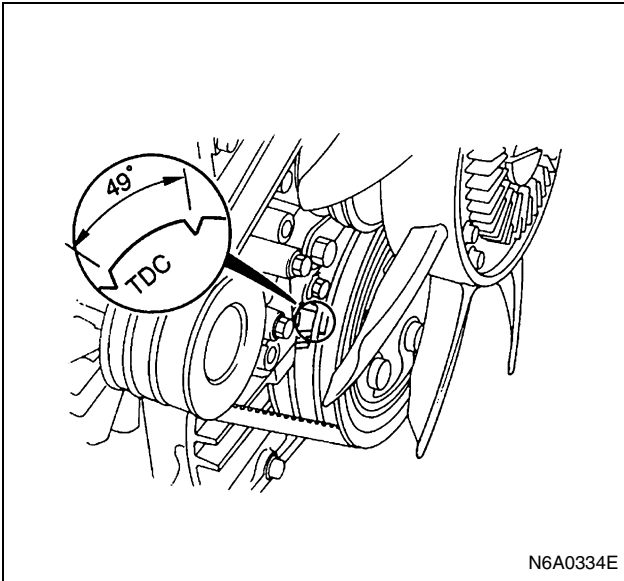
- 11) Install the inspection hole plug.

Tighten:

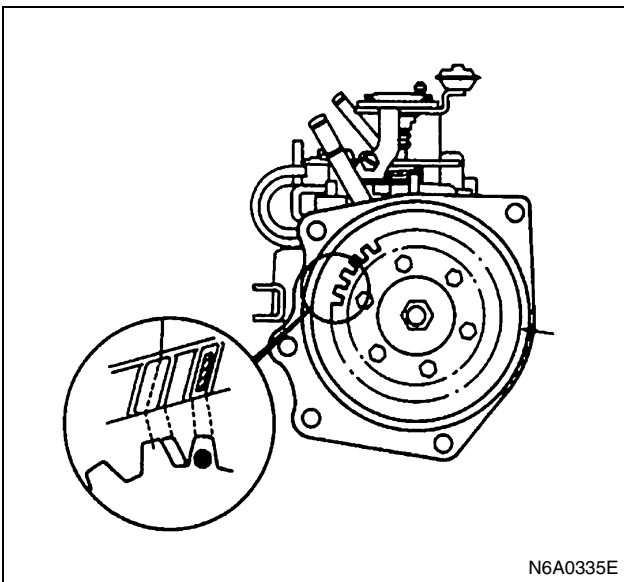
Inspection hole plug to 48 N·m (4.9 kg·m / 35 lb·ft)

41. Injection Pump Assembly (4HF1-2 model only)

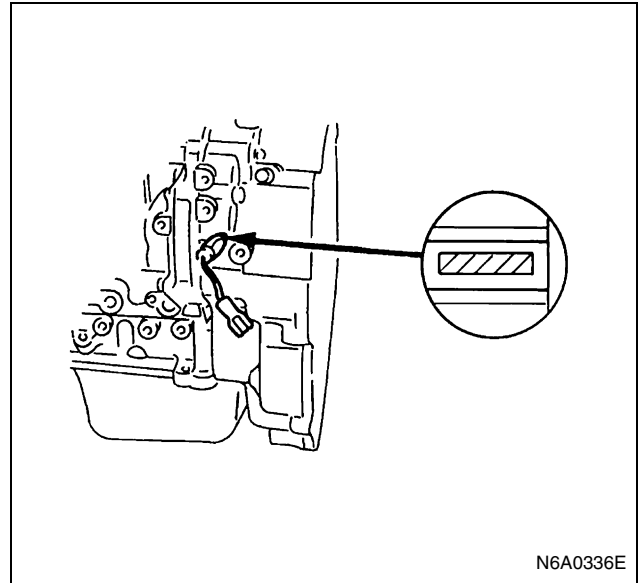
- 1) Turn the crankshaft to set No.1 cylinder to 49° before TDC in its compression stroke.
(49° is a pump installing alignment angle, not related to injection timing.)



- 2) Install O-ring to the injection pump.
- 3) Apply paint on the • (Z) marked side of the injection pump gear.
- 4) Align the pump bracket mark with the tooth (under side of the pump) just before the • (Z) marked tooth.



- 5) Insert the pump using the block side of stud bolt as a guide.
- 6) After installing the injection pump, remove the tachometer sensor from the housing, and make sure that the painted gear is at the center of the sensor mounting hole.



- 7) Tighten injection pump clamping bolt and nut to specified torque:

Tighten:

Bolt to 48 N·m (4.9 kg·m / 35 lb·ft)

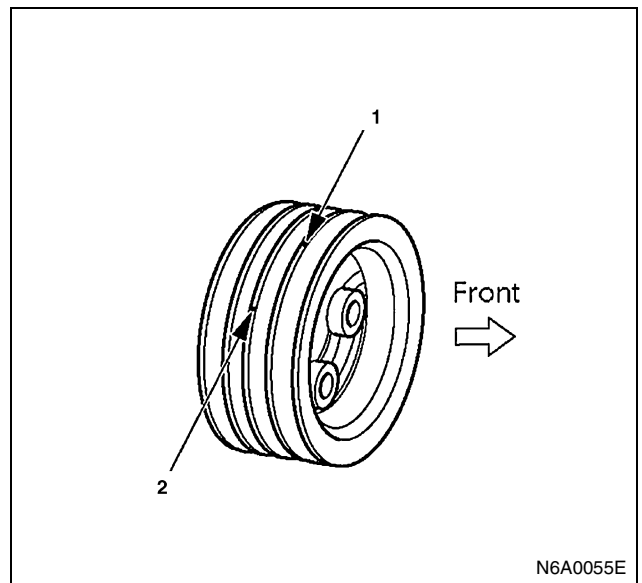
Tighten:

Nut to 24 N·m (2.4 kg·m / 17 lb·ft)

- 8) With reference to Injection Timing Check & Adjustment, set No. 1 Cylinder to 12° before its TDC.

Notice:

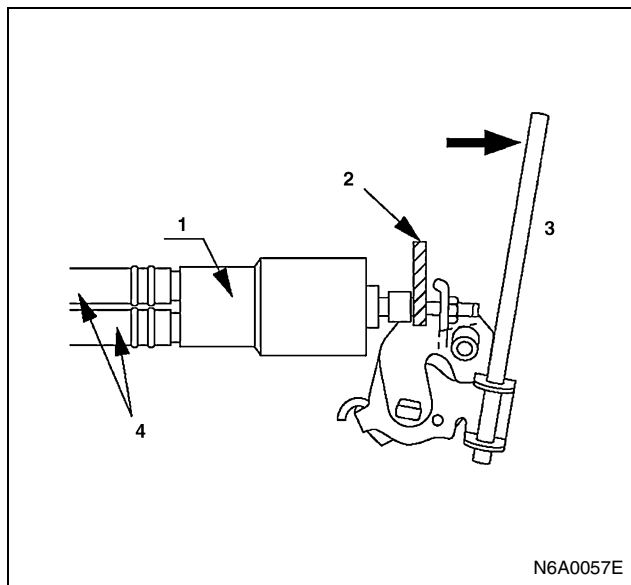
In case the crank pulley has two marks as illustrated (1), BTDC 49° mark on the second crest and (2) TDC mark on the third crest (as viewed from the front side), be sure to set at the mark (2). (If there are two different marks on one and same crest, set at the mark which comes second when rotated in the normal direction.)



42. Injection Timing Check (4HF1-2 model only)

- 1) Set No. 1 Cylinder to the TDC in the compression stroke.

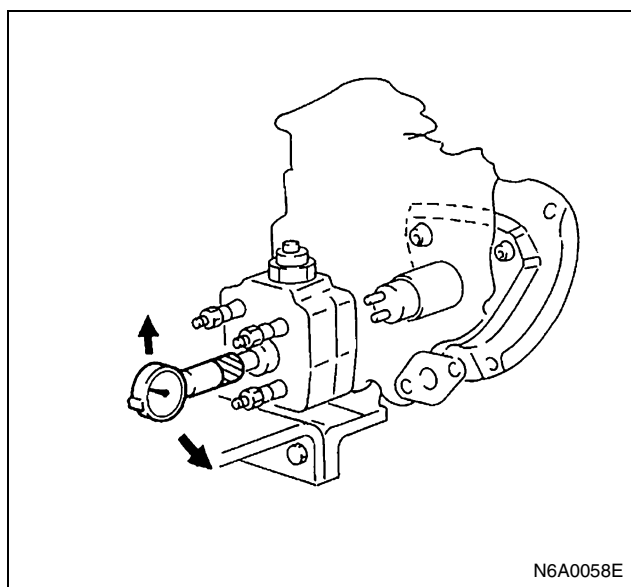
- 2) Disconnect Injection Pipe.
- 3) Put down Wax CSD lever, insert a spacer 10 — 20 mm (0.39 — 0.47 in) thick between the plunger and adjust bolt, and cancel the Wax CSD.



Legend

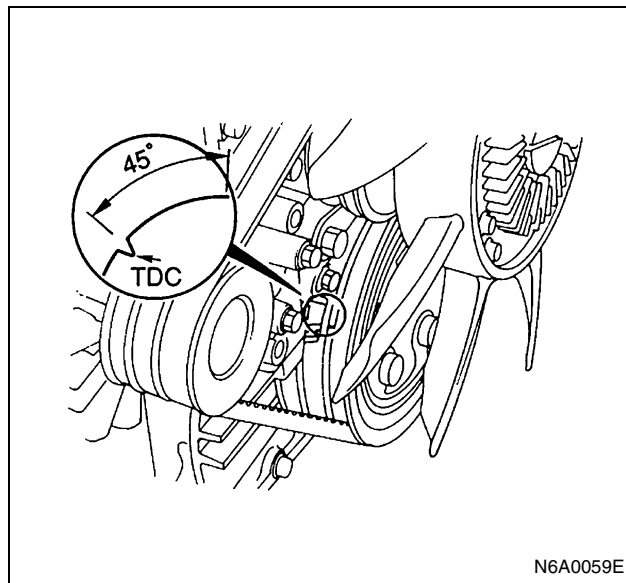
1. Water house
2. Wax CSD
3. Spacer
4. Lever

- 4) Remove the pump rear plug, connect a dial gage and set the lift at 1 mm (0.039 in).
Special Tool
Measuring device: 5-8840-0145-0



- 5) Set the crankshaft damper pulley TDC mark to the pointer or 45° before TDC.
- 6) Set the dial gage to the "0" position.

- 7) Turn the crankshaft leftwise and rightwise a little and make sure that the needle stays in the "0" position.

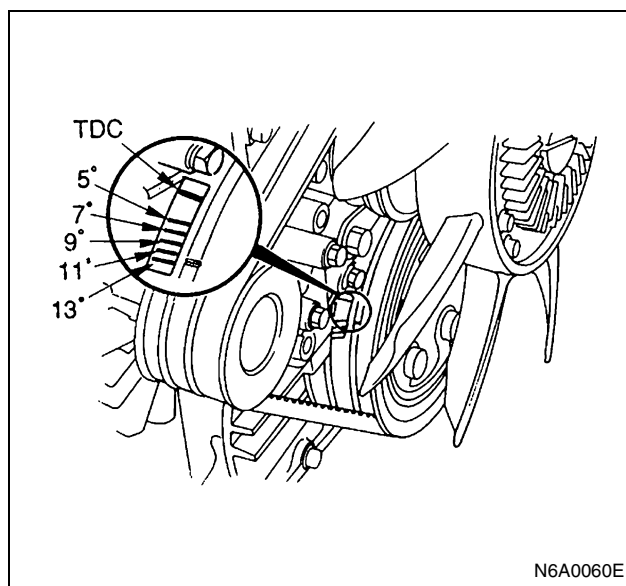


- 8) Turn the crankshaft in the normal direction and read the measuring device's indication at the 12° before TDC position.

Notice:

As there is no 12° mark, set midway between the 11° and 13 marks.

Standard value: 0.5 mm (0.0197 in)



43. Injection Timing Adjustment (4HF1-2 model only)
If injection timing is out of the specified range, follow the following procedure for adjustment:

- 1) Loosen injection pump fixing nuts and bracket bolt.
- 2) Adjust the mounting angle of injection pump:
 - If injection timing is too fast, bring the injection pump closer to the engine.
 - If injection timing is too slow, put the injection pump more distant from the engine.

- 3) When the dial gage has indicated the specified value, tighten the fixing nuts and bolt to specified torque:

Tighten:

Nut to 24 N·m (2.4 kg·m / 17 lb·ft)

Tighten:

Bolt to 48 N·m (4.9 kg·m / 35 lb·ft)

- 4) Disconnect the dial gage, install and tighten the plug to specified torque. (Make sure of a copper washer being attached to the plug)

Tighten:

Pump rear plug to 17 N·m (1.7 kg·m / 12 lb·ft)

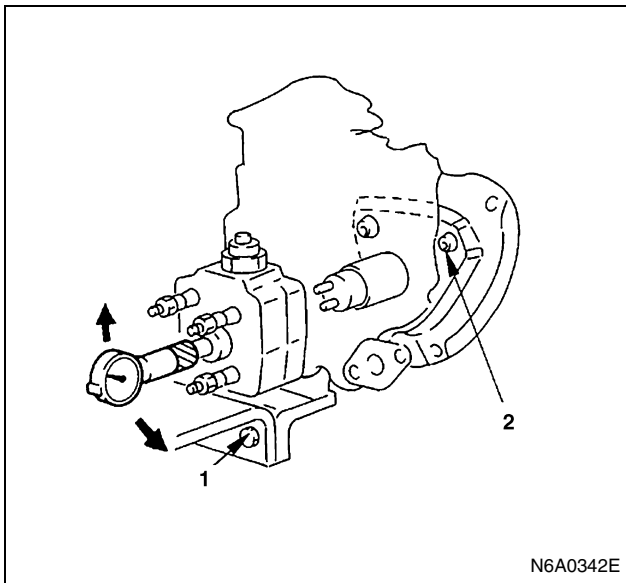
- 5) Release the wax CSD and connect the injection pipe.

Tighten:

Pipe sleeve to 29 N·m (3.0 kg·m / 22 lb·ft)

Notice:

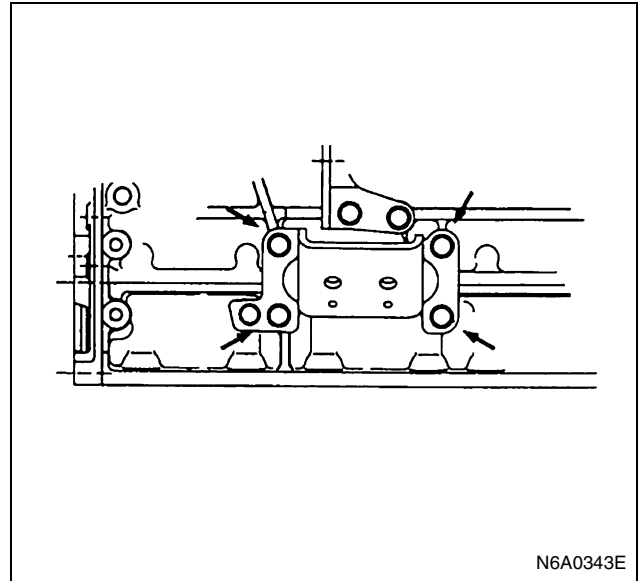
If there are two marks on the crank pulley, the front side of mark is for setting BTDC 49° and the rear side of mark is for setting TDC.

**Legend**

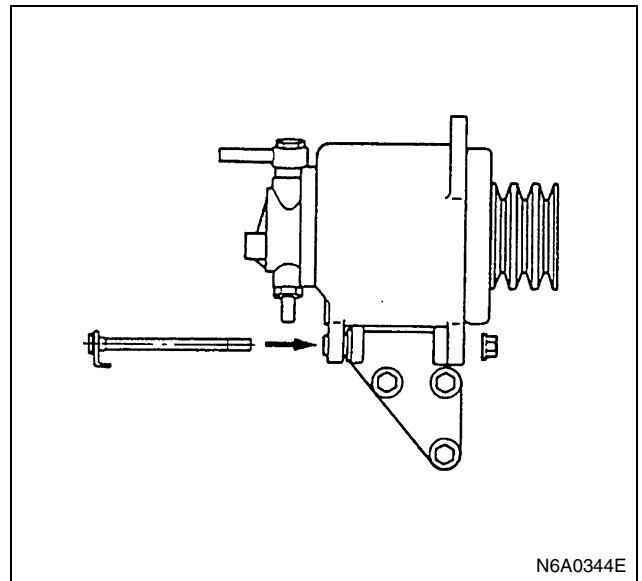
1. Bolts
2. Nuts

44. Engine Foot**Tighten:**

Engine foot bolt to 51 N·m (5.2 kg·m / 38 lb·ft)

**45. Generator****Notice:**

Before tightening the generator securely, tighten it temporarily in advance after adjusting the fan belt. Put the lower fixing bolt through from the rear side and tighten it with the nut on the front side as shown in the illustration.

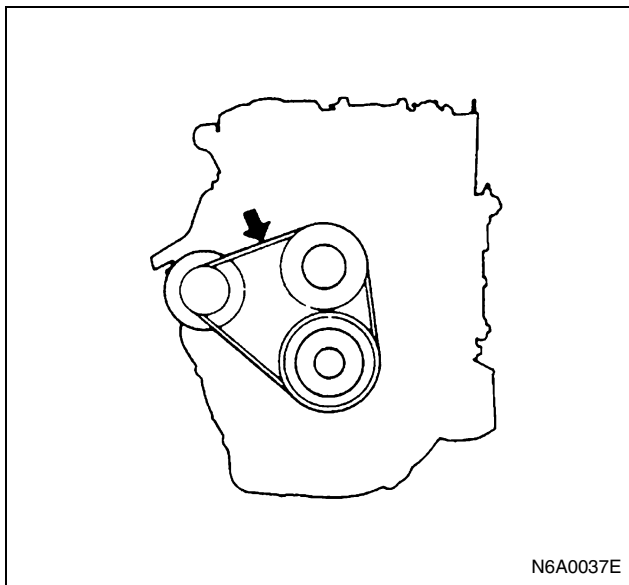
**46. Fan Belt**

Check the drive belt tension.

Depress the drive belt mid-portion with a 10 kg (22 lb / 98 N) force.

Drive Belt Deflection		mm (in)
New belt	8 — 12	(0.31 — 0.47)
Reuse belt	10 — 14	(0.39 — 0.55)

Check the drive belt for cranking and other damage.



N6A0037E

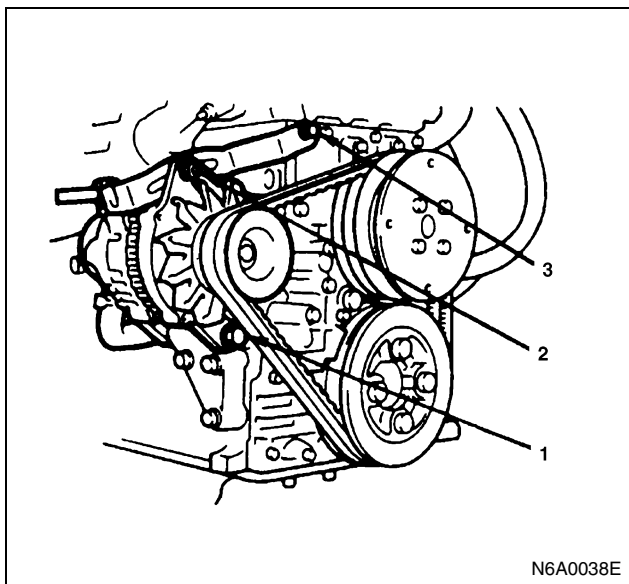
47. Fan Belt Adjustment

Fan belt tension is adjusted by moving the alternator.

Tighten:

Bolt to

- (1): 40 N·m (4.1 kg·m / 30 lb·ft)
- (2): 24 N·m (2.4 kg·m / 17 lb·ft)
- (3): 46 N·m (4.7 kg·m / 34 lb·ft)



N6A0038E

48. Vacuum Pump Rubber Hose

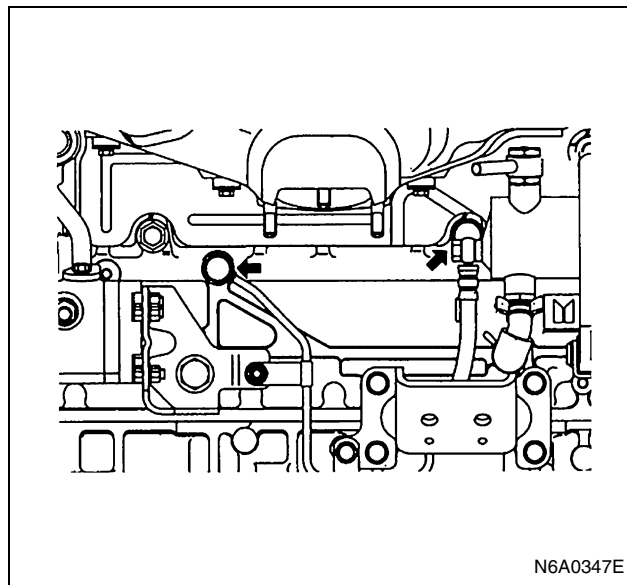
49. Vacuum Pump Oil Pipe

Tighten:

Cylinder body side pipe to 41 N·m (4.2 kg·m / 30 lb·ft)

Tighten:

Generator side pipe to 23 N·m (2.3 kg·m / 17 lb·ft)



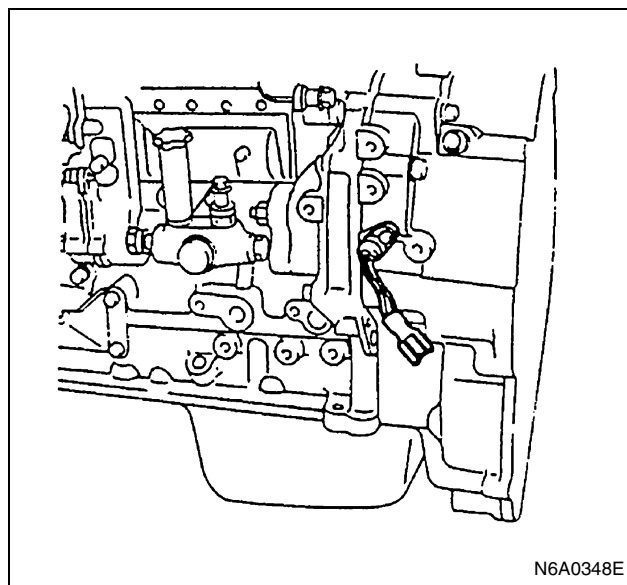
N6A0347E

50. Fuel Pipe Bracket

51. Tachometer Sensor

Tighten:

Tachometer bolt to 8 N·m (0.8 kg·m / 6 lb·ft)



N6A0348E

52. Oil Filter Assembly

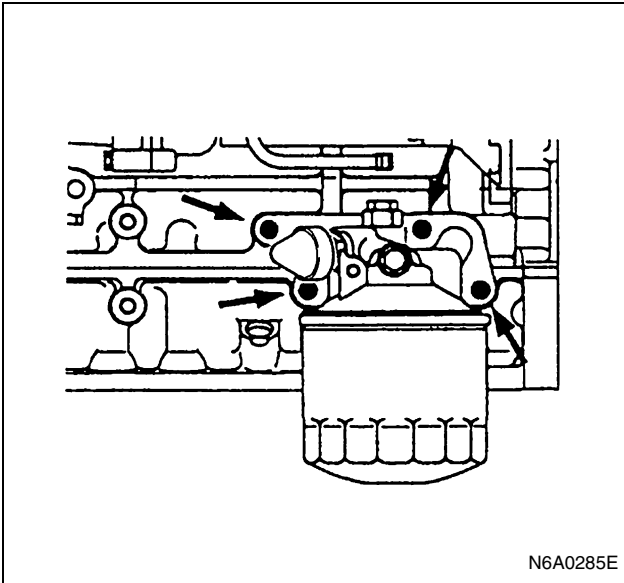
Tighten:

Oil filter bolt to 48 N·m (4.9 kg·m / 35 lb·ft)

53. Oil Pipe

Tighten:

Oil pipe joint bolt to 17 N·m (1.7 kg·m / 12 lb·ft)

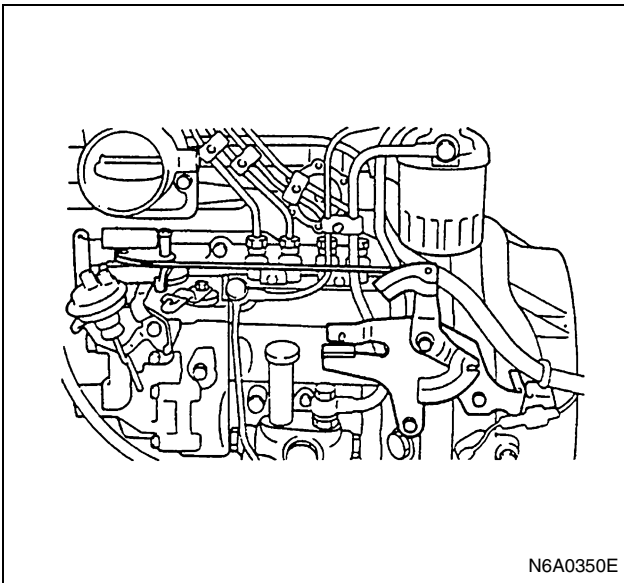


54. Engine Control Lever Assembly

Tighten:

Engine control lever bolt to 24 N·m (2.4 kg·m / 17 lb·ft)

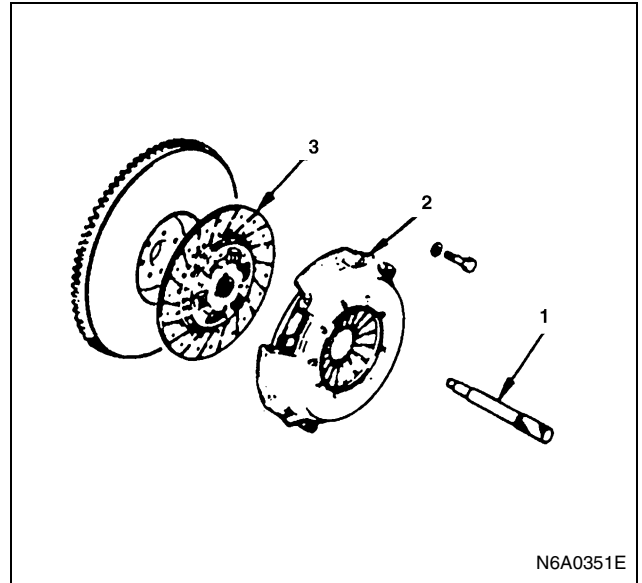
55. Engine Control Wire



56. Driven Plate

Use the clutch pilot aligner to install the driven plate.

Clutch Pilot Aligner: 5-8840-2240-0



Legend

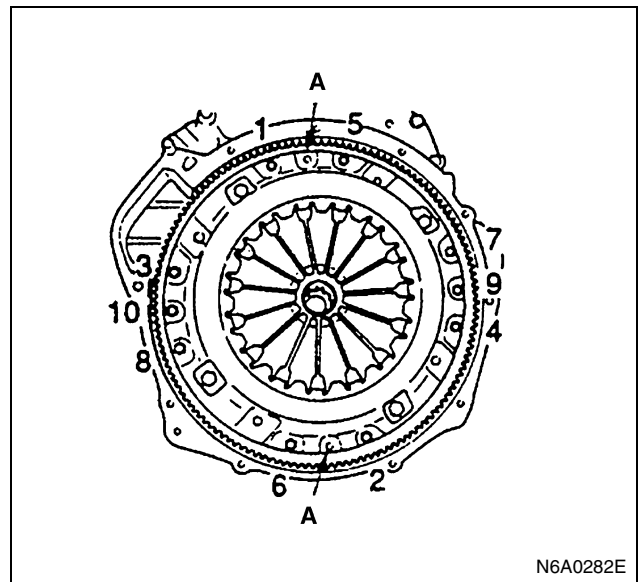
1. Clutch pilot aligner
2. Clutch pressure plate assembly
3. Driven plate

57. Clutch Pressure Plate Assembly

- 1) Align the clutch pressure plate with the flywheel knock pin.
- 2) Tighten the pressure plate bolts to the specified torque in numerical order.

Tighten:

Clutch pressure plate bolt to 40 N·m (4.1 kg·m / 30 lb·ft)



Legend

- A. Knock pin

58. Cylinder Head Gasket

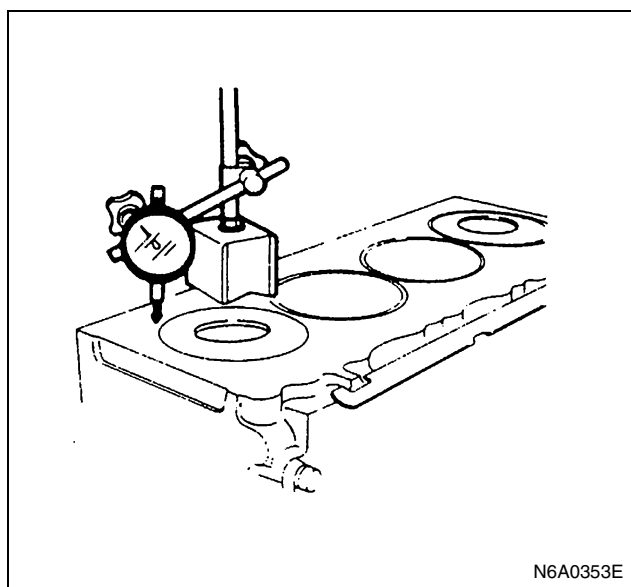
- 1) When any of the cylinder block, crankshaft, crankshaft bearing, connecting rod, connecting rod bearing, and piston is replaced with a new one, cylinder head gasket thickness should be determined newly.
- 2) When replacing the cylinder head gasket alone without replacing any of the parts mentioned in 1) above, the gasket to be used should be the same grade as the one used before.
- 3) Correct the cylinder head gasket thickness is important. Installing the wrong thickness gasket can result in greatly reduced engine performance.
- 4) There are three cylinder head gaskets available.

59. Piston Head Projection Measurement

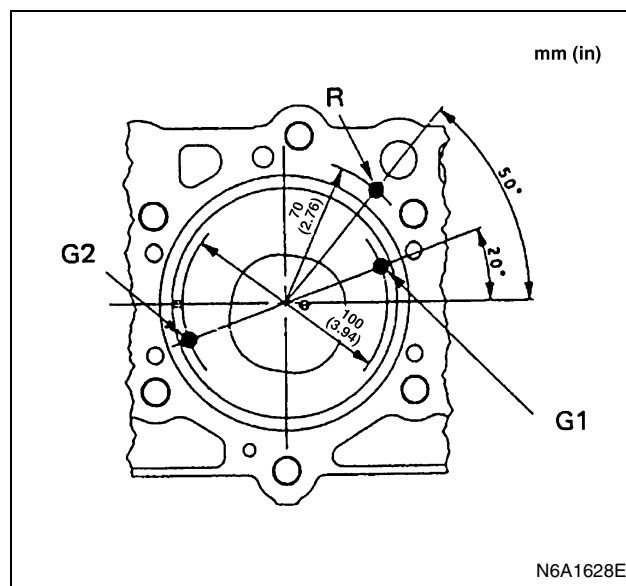
- Select a cylinder head gasket.
- Clean thoroughly the top faces of the piston head and the cylinder body.
- Use the dial gauge to measure the piston head projection. Take measurements at two locations for each cylinder.
- The measurement points of the piston head and the reference point of the cylinder body are shown in the illustration.

Measurement points: Points G1 and G2 of the piston head

Reference point: Point R on the top face of the cylinder body

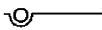
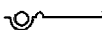
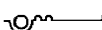


- Based on the Timax obtained, select a gasket of the appropriate grade.



4HF1/4HF1-2/4HG1-T

Cylinder Head Gasket Selection

mm (in)		
Gasket Grade	Ti max	Gasket Thickness (Reference)
A 	0.579 - 0.659 (0.0228 - 0.0259)	1.70 (0.0669)
B 	0.659 - 0.739 (0.0259 - 0.0291)	1.75 (0.0689)
C 	0.739 - 0.819 (0.0291 - 0.0322)	1.80 (0.0708)

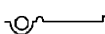
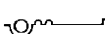
N6A1396E

Notice:

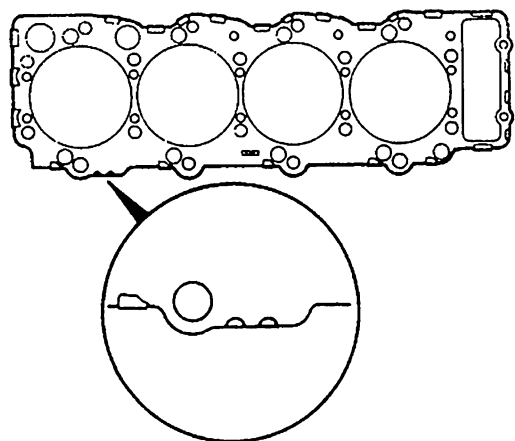
Note that there are three types of a cylinder head gasket available as shown in the table following, according to the piston projection.

- For each cylinder, calculate the average value (Ti) of the piston projection.
- Find the maximum value (Timax) of the average value (Ti) of each cylinder.

4HE1-TC**Cylinder Head Gasket Selection**

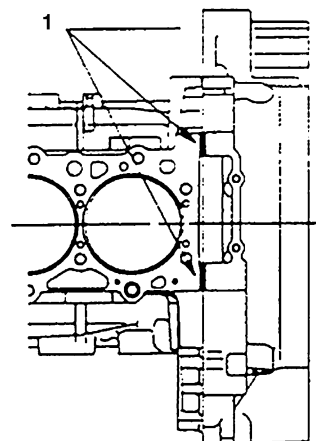
Gasket Grade	Ti max	mm (in)
		Gasket Thickness (Reference)
A 	0.529 - 0.609 (0.0208 - 0.0240)	1.70 (0.0669)
B 	0.609 - 0.679 (0.0240 - 0.0267)	1.75 (0.0689)
C 	0.679 - 0.759 (0.0267 - 0.0300)	1.80 (0.0708)

N6A1397E



N6A0353E

- Apply a 3 mm (0.12 in) bead or recommended liquid gasket or its equivalent to the shaded areas shown in the illustration.



N6A0356E

Legend

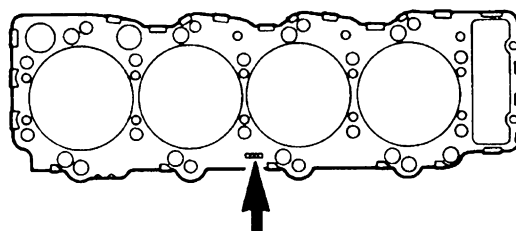
1. Bead width $\phi 3$

- Install the cylinder head gasket with its "PART NUMBER" mark facing up and toward the left of the engine.

Caution:

Do not reuse the cylinder head gasket.

60. Cylinder Head Assembly
Above works refer to "CYLINDER HEAD" section 6A3 in this manual.



N6A0105E

